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AN OUTLINE OF MODERN KNOWLEDGE

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ON

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INTRODUCTION

The progress of scientific study and experiment during the present century, and more particularly since the War, has done more than add to the sum of facts. The whole outlook has changed and is changing. The materialistic and mechanistic views of last century, encouraged and strengthened by the biological discoveries of Darwin, are giving place to speculations which are in danger of falling into the abyss of mysticism. Yet, as Professor Wolf points out, matter remains matter, however our conceptions of its nature may change, and it is still too early to state the precise implications of the new discoveries and theories. Man, in his present condition, represents a stage in an evolutionary process which is still going on, and all the efforts of scientists are ultimately directed towards the one end—to reveal the nature of man's existence and the universe of whose creative forces he is, so far as we know, the crowning achievement.

The sciences can no longer work independently. They are all branches of one great investigation, and the discoveries of one react upon the other. All are liable to be influenced by any change of outlook which may come about through the advances of any one of them, and the progress of one science may be conditioned by new methods and discoveries in another. A channel of inquiry may even be blocked before the goal is reached, and the physicist, for example, who can tell us about the structure and behaviour of things, may, if mind should prove to be the ultimate reality, have eventually to leave to the psychologist the task of explaining what matter *is*. Fields of study are becoming ever smaller, but are, at the same time, undergoing a process of liberation. Science has become divorced from philosophy; philosophy is no longer expected to subserve the interests of theology; psychology is standing on its own feet; psycho-analysis, the offspring of psychology and medicine, though one of the youngest of the sciences, is yet including every aspect of man's activity in its domain—and the process of differentiation is being continued even in psycho-analysis, which has split up into three schools, one of which denies the title to the other two. Scientific investigation is thus becoming more departmentalised; each worker finds himself compelled to devote his mind and energies to a more restricted field, and the prospects of a final synthesis are growing more remote. It is true that attempts are being made every day to present to the lay public an exposition of one science or of all sciences, with a view to presenting the conclusions of theory and investigation in a form which will be easily intelligible to the inquirer who wishes to overleap the laborious stages by which generations of scholars have contributed to present results. But it is not possible to popularise to more than a certain extent without putting matters so simply that the explanation ceases to be true.

The planning of the present book was therefore based on the assumption that the only way to provide a conspectus of the actual achievements of scholarship and thought would be in a sufficient number of presentations by leading authorities who are themselves original investigators in the essential fields of study. Each contributor outlines the past history of his subject before leading up to an exposition of the present state of knowledge and the relation of his field of work to the life and thought of to-day. Each Article has been specially written for this book, and there has been sufficient discussion between the editor and the contributors, and between the contributors themselves, to ensure that it shall fit into its place in the general plan. An essential condition of the success of the book's intention was that simplification should not be carried to the stage which must inevitably result in distortion, yet that the thought in each contribution should be developed with a gradualness and lucidity which would make every successive point crystal clear to the reader who comes fresh to the subject. Each reader will be able to make his own synthesis, in so far as any kind of synthesis is possible, and will be helped towards an understanding of the fundamental problem which mankind has still to solve—the problem of life itself, with the questions it entails of free-will and survival.

All study is intimately bound up with the fate of man, and these Articles all have a bearing on his provenance and destiny, on both the realised and unconscious purport of his activities and the significance of the physical and spiritual forces, the external and the internal influences, which are affecting him for good or for ill. They show how science, philosophy, psychology, historiography and economics, together with the study of art in its various forms, are delving into the nature of existence, considering it not only in the light of what has gone before, but in view of the goal to which man and the universe may be tending. In the words of Dr. Marett : " To consider ourselves in the light of what we may reasonably hope to become is our first and last duty as self-directing beings." If we ask what is the value of the study of the past, Professor Hearnshaw points out that its aim is the explanation and elucidation of the present, that the purpose of the historian is to attain to an understanding both of his environment and of himself. If we ask what science is doing, and what we may expect it to do, towards giving man power over his future development, Professor Crew contemplates the eventual control of biological functions for furthering the happiness and progress of mankind, and Professor Flügel holds out the promise that psycho-analysis may enable us to become more conscious of ourselves, and thus extend our powers of rational insight and control. We may therefore look forward to the time when man will be master in his world, when he will be able to regulate some, at any rate, of the physical and mental forces of which he is at present largely the plaything. Mr. Fry, on the other hand, points to an activity which appears to be " biologically useless," a purely spiritual activity analogous to that which impels men to search for truth, and suggests that this is responsible for our most cherished works of art. It is also, in fact, responsible for some of the finest scientific achievements of the human mind, and the æsthetic element in their work is recognised by some scientists. Neither can it be denied, to take the

other side of the picture, that there is a scientific aspect to the search for beauty.

The scientist cannot define matter nor state the precise nature of sex, not because he knows little about them, but because he knows so much. Yet religious leaders, politicians, and economists have based their doctrines on scientific theories which have now to be cast into the limbo of outworn beliefs, and, though the theories be discarded, the doctrines are often slow to follow. Even art cannot divorce itself from the changes that take place in the realms of science and philosophy. The Naturalist movement towards the end of last century, which was the literary culmination of the growing sense of reality among imaginative writers, was closely bound up with the trend of thought that was due to the theory of organic evolution, and much of the most significant literature of the post-War years would have been unthinkable without the revolution in the outlook of physical science and the discoveries of the new psychology of the unconscious. The Naturalists thought they could photograph reality. We are now asking, " What *is* reality ? "

The composite view of the universe is no longer systematic, or even intelligible, but at the same time as it is being widened and deepened it is growing more confused. In so far as it is possible to construct a clear picture, which must necessarily be in the nature of a mosaic, of the present achievements of human thought and knowledge, and to summarise the evidence which may point to a directive or purposive agency in the universe, this book attempts to do so.

WILLIAM ROSE.

AN OUTLINE OF MODERN KNOWLEDGE

A PHILOSOPHIC AND SCIENTIFIC RETROSPECT

By

A. WOLF

SYNOPSIS

ANCIENT TIMES. Man's emergence from the mythological stage — The beginnings of philosophic and scientific thought among the Greek colonists in Asia Minor — The early nature philosophers before the age of Socrates — The golden age of Greek thought in Athens : Socrates, Plato, and Aristotle — Their successors — Philosophy and science in Alexandria, the greatest meeting place of East and West — The end of Antiquity — The closing of the Schools in A.D. 529.

THE MIDDLE AGES. Philosophy in Islam and among the Jews in Moslem countries — The Fathers of the Church and the Scholastic philosophers — Science in the Middle Ages — The Renaissance, the Reformation, the Copernican revolution, and the transition to the modern period.

MODERN TIMES. Gradual emancipation from bondage to authority — Science in the seventeenth century — Philosophy in the seventeenth century — Philosophy in the eighteenth century — Science in the eighteenth century — Philosophy in the nineteenth century — Science in the nineteenth century — The predominance of idealism in philosophy, and of materialism in science during the middle decades of the nineteenth century.

A PHILOSOPHIC AND SCIENTIFIC RETROSPECT

The belief in evolution is sufficiently wide-spread and deep-rooted by now to incline intelligent people to suppose that no period of human thought, not even the latest scientific and philosophic theories, can be regarded as isolated and self-contained. In one way or another, usually in many ways, each intellectual era has its preparatory historical antecedents, a knowledge of which makes it more intelligible than it would be otherwise, helps people to exercise moderation in their expectations from the latest ideas, and to spare themselves the shock which is apt to come to those who fail to appreciate the inevitableness of incessant change in man's intellectual orientation. Thoughtful people have long since realized that the *latest* word in science or philosophy is by no means the *last* word, and that probably there is no last word in these great enterprises of the human spirit. This is no ground for discouragement. The spirit of an age, as of an individual, must be judged, not by the finality of its achievement, but by the seriousness of its endeavours in the light of its own day; and the very absence of finality leaves ample scope for succeeding generations to carry on the ceaseless quest. And the quest is not altogether in vain. Absolute aberration appears to be a rare phenomenon in the history of human thought. For the most part the intellectual achievements of past ages not only serve a useful temporary purpose but also embody something of more enduring value. Indeed, to the student of the history of human thought one of the most surprising things is the persistence throughout the ages of the same stock of fundamental ideas, which are often modified and refined in many ways but are never abandoned entirely. Be that as it may, the human quest for truth is certainly one of the greatest enterprises of man, if not the greatest of them; and the story of that quest has an intrinsic interest of its own, besides affording some help to the understanding of the present and of its roots in the past.

ANCIENT TIMES

Of the period of two hundred and fifty thousand years or more that the human race has already been in existence, only a very small fraction comes within the purview of the historian of human thought. The great bulk of that long period was consumed in the struggle for bare existence amid the destructive forces of nature. Man had to act long before he could think. He had to react to his physical environment long before he had the capacity or the leisure to try to understand it. The life-and-death struggle prompted by the will to live, and later by the will to power, was no doubt haunted from an early period by a certain vague sense of wonder and bewilderment. And to this day something of that sense of wonder and bewilderment may haunt the performance of religious rites, which are the offspring of those magic performances by which early

man endeavoured to control and to compel, or to coax and appease, the deified forces of nature on which he felt himself so dependent. In course of time mythologies and other more intellectual explanations were attached to the primitive ritual. The explanations change from time to time according to the intellectual level of the age, but the emotional element associated with the religious ritual may continue more or less the same, reminiscent perhaps of that vague sense of wonder and bewilderment which haunted primitive man already at the pre-intellectual stage of human existence.

Some vague notion of cosmic orderliness may be discerned already at the mythological stage of human thought. Early Greek mythology, for instance, introduces the figure of Nemesis, the goddess who checks and controls the wild things in nature and so maintains some measure of order in nature. It is true, of course, that in the mythology of the Greeks a considerable rôle is played by Pan, the goat-footed and goat-minded lord of lawlessness. This is natural enough, for the wildness and rough play of natural forces seem to lie on the surface of things, and so impress one first of all. It is therefore all the more significant that some idea of order, in physical nature and in human life, should have emerged so early. The conception of order among the phenomena of nature appears to have grown *pari passu* with the growth of order in human societies. The use of the term "law" to express the regularity of natural phenomena is clearly reminiscent of the "law and order" decreed and enforced by a sovereign power in a society; and to this day some people cannot divorce the notion of "law" from that of a legislator.

The transition from a mythological view of natural events to a more scientific and philosophical attitude was a very slow one, and even when it was accomplished the separation was not quite complete. For the more scientific attitude was the result of an increasing rationalization of mythological ideas, which may often be traced easily in their more intellectual transformations. Thus, for instance, the water in which Thales found the origin of all things is reminiscent of Osiris; the fire to which Heraclitus traced everything recalls the sun-god Ra; and Nemesis reappears in the "avenging spirits" which, according to the same Heraclitus, keep the sun within his orbit. In this kind of way it would be possible, if one had the time and the patience, to decipher the palimpsest of human thought throughout the ages. But that is unnecessary for the present purpose. It is enough to point out that when scientific and philosophic thought, as distinguished from mythological thought, made its first appearance, on the Western coast of Asia Minor, it was indebted to no small extent to the preceding mythological thought throughout the then civilized world, as well as to the many practical achievements of Egypt and Mesopotamia, and probably of other countries also. Western thought, however, during the past twenty-five centuries or so, is sufficiently comprehensive and self-contained to justify our confining our attention to it.

Pre-Socratic Thinkers

One of the persistent questions in the history of human thought refers to the nature of the ultimate stuff, or substance, of which all things

are composed and to which they eventually revert. For some reason or other the human mind always inclined to assume that the vast diversity of objects which make up the visible world is at bottom made up of the same stuff, and tried to determine what that ultimate stuff is. This question was first raised and answered in a non-mythological manner by a group of Greek thinkers who lived in Ionia, on the west coast of Asia Minor. The answer was crude. Thales (*c.* 640–550 B.C.) suggested that water was the primary stuff. Anaximenes (*c.* 590–525 B.C.) suggested air; and Anaximander (*c.* 610–545 B.C.) made the more deep-sighted suggestion that the primary stuff must be something different from the various determinate forms of matter known to us, and so described it simply as the "boundless" or "indeterminate," out of which such determinate substances as fire, air, water and earth "separated out" or were differentiated. The merely mythological stage was thus passed. They no longer asked *who* created the world of things, but *what* was the stuff of which they were made; and in place of the mythological processes based on the analogy of child-birth, Anaximenes suggested the processes of condensation and rarefaction as the processes by which the primary matter became transformed into the great variety of familiar things. These early thinkers traced the origin of all things to a material basis and to material processes, yet it would not be right to describe them as materialists, because the hard and fast distinction between mind and matter was alien to their ways of thinking. For them, and for the Greeks generally, matter was something living. They were *hylozoists*, not materialists: they regarded all things as composed, not of dead inert matter, but of living substance.

A more subtle conception of the nature of the ultimate principle (or primary stuff) of things was introduced by Pythagoras (*c.* 570–500 B.C.) and his school. They laid stress on the *form*, rather than on the matter, of things as constituting their permanent reality. The study of music led them to the discovery of the importance of *proportion* (say, between the lengths of strings and the notes which could be produced on them). This idea was applied by them in every possible direction. The health of a body, for example, was regarded as resulting from a certain proportion between its elementary qualities (hot and cold, dry and wet); other proportions between them would lead to various diseases. Extending this conception, they maintained that the principle or essence of all things is to be found in their several *forms*. They expressed this view in the dictum that "all things are numbers." Numbers and forms were easily identified in those days, because numbers were frequently represented by dots arranged in certain geometrical forms or patterns (as they still are on dominoes and cards). This custom rather encouraged the Pythagorean view, or at least made it seem plausible. For the unit of number was easily identified with the dot or point. Now, lines can be analysed into points, planes into lines, and solids into planes. This made it appear that points make lines, which make planes, which make solids. So the identification of the point with the unit of number readily made it appear that "all things are numbers" or made up of numbers. In one way or another the belief in the supreme importance of mathematics in science has maintained itself ever since the days of the Pythagoreans.

The Pythagorean School had been founded in Southern Italy by a refugee from Ionia, after the Persians had conquered it. The Persian conquest of Ionia filled the suffering Greeks with a kind of religious revival. The Pythagorean School was a kind of religious brotherhood with a philosophical bias. But the secular spirit was maintained and sharpened by other Greek thinkers, in Elea, in Southern Italy. Noteworthy among these is Xenophanes (*c.* 570–480 B.C.), who made a scathing attack on the current conception of the gods. "Mortals [he said] believe that the gods come into being as they themselves do, that they have senses, voice, body. . . . But if oxen or lions had hands, oxen would make gods like oxen, horses would make gods like horses." Strongly opposed to the religious anthropomorphism (the tendency to regard God, or the gods, as like men) and polytheism of his time, he believed in "one supreme God . . . like unto mortals neither in body nor in thought." According to the reports of Aristotle, Xenophanes was the first Western monist and pantheist. He is usually regarded as the author of the statement: "The All is One, and the One is God." (The first part of this statement expresses his monism; the second part, his pantheism.) The monistic philosophy of Xenophanes was strongly supported by other Eleatic philosophers, notably by Parmenides (*c.* 540–480 B.C.) and Zeno (*c.* 490–420 B.C.). Parmenides considered it unthinkable that things should come into existence out of nothing, or that they should ever dissolve into nothingness. He maintained, accordingly, that the world is one, uncreated and imperishable reality. Motion and other kinds of change, and the discreteness of ordinary things, he regarded as illusory appearances. Zeno's famous paradoxes were meant to show that a pluralistic conception of the world involved absurdities. Perhaps the most striking feature in the views of the Eleatic thinkers is their stress on *thought* as the only source of real knowledge, the senses being regarded as illusory.

In opposition to the Eleatics, Heraclitus (*c.* 540–475 B.C.) emphasized the multiplicity of things and their incessant change, though he shared the Eleatic view of the eternity of primary matter. His conception of the cosmic process was that of periodic cycles of change, each cycle beginning and ending in a mass of fire. Perhaps the most valuable thing in the teaching of Heraclitus was his stress on the orderliness of natural events—all changes, he insisted, occur "by measure." This regularity, moreover, was regarded as evidence of the existence of "universal reason" either in primary matter or side by side with it. Pluralism was carried a stage further by Anaxagoras (*c.* 500–428 B.C.) and Empedocles (*c.* 483–430 B.C.), and culminated in the atomic theory of Democritus (*c.* 460–370 B.C.). Anaxagoras held that there is not one kind of primary stuff, but a great variety of "seeds" of things through the various combinations of which all sorts of different objects are produced. Empedocles substituted the idea of four "roots" for that of the numerous "seeds" of Anaxagoras. The "four roots" of things were the familiar "four elements"—fire, air, water, earth. To account for the combination and separation of these elements he formulated two principles of attraction and repulsion (or "love" and "hate," as he called them). The atomic tendency of Empedocles betrayed him into some curious biological speculations. He

suggested that the several parts of the living body existed separately at first, and then combined in all sorts of ways (like the " roots " of matter). But he has the merit of having suggested also the first notion of " the survival of the fittest." For he held that of all the numerous combinations of the parts of living bodies, only those survived which were fit to live.

The atomic theory appears to have been first formulated by Leucippus (*c.* 500–430 B.C.), but is usually associated with the name of his follower Democritus, who is consequently known as " the father of physics." According to Democritus, the only ultimate realities are atoms and space. The atoms vary in size and shape, and all compound bodies are made up of them. The differences found among compound bodies are due partly to the differences in shape and size of the atoms of which they are composed, partly to the position of the atoms, and partly to their arrangement in the composite bodies. The atoms, in short, were regarded as the alphabet of the universe, and the differences just referred to may be illustrated by means of letters of the alphabet. Thus, for instance, A and M differ in shape and size; M and W differ in position (invert either and you get the other); ON and NO differ in arrangement. The last of these differences recalls the " form " of the Pythagoreans. The atoms, according to Democritus, are not inert, but endowed with motion. This view of the atoms avoided the difficulty (which perplexed subsequent thinkers until the age of Newton) as to how inert matter was first set in motion. The atoms moving about spontaneously in all directions get entangled with one another and so form composite bodies of all kinds, including whole worlds. Under suitable conditions also such composite bodies collide with one another, and some of them break up again into separate atoms. The atomic theory thus attempted a purely " mechanical " explanation of the universe, that is, an explanation solely in terms of matter and motion. This involved the denial of the objective reality of the so-called " secondary " qualities (colours and sounds, smells and tastes, etc.), which could not be explained mechanically. " According to *convention* [Democritus is reported to have said], there is a sweet and a bitter, a hot and a cold, and according to convention there is colour. In *truth* there are atoms and a void." The contrast between the *conventionally* right and what is *truly* (or objectively) right had been made current by the Sophists. And the Atomists adopted the distinction for their own purposes. To describe the secondary qualities as " conventional " was tantamount to a denial of their objective reality and to reducing them to the subjective status of illusions. The atomic theory continued to enjoy considerable popularity throughout the subsequent history of human thought, though it has undergone many and important changes with the development of experimental physics and chemistry.

The Persian conquest of Ionia, we have seen, led to the dispersal of the Ionian philosophers, and so to the spread of philosophic interest elsewhere. Of far greater importance was the subsequent triumph of the Greeks over the Persians. This great upheaval produced a spirit of dissatisfaction with existing conditions and current beliefs, and awakened a wide-spread interest in knowledge. A class of professional teachers responded to the demand. These were the " Sophists " or " wise men." They did much for the spread of general education, and by their criticism

of current beliefs compelled other thinkers to probe deeply into the great problems of human life. It was they who gave currency to the distinction between mere convention and intrinsic value, and directed special attention to problems of specifically human interest. The most familiar doctrine associated with the Sophists is that contained in the dictum of Protagoras : " Man is the measure of things." This dictum is frequently regarded as an anticipation of the very much later pragmatism (or humanism) in its stress on the relativity of truth and goodness to the practical needs of man. It was in the period of the Sophists that Athens first became the centre of Greek philosophy, which attained its golden age in the genius of Socrates, Plato and Aristotle.

The Golden Age of Greece

Socrates (469–399) shared some of the views and interests of the Sophists, and his contemporaries mostly regarded him as one of them. For, like the Sophists, he also tried to promote general education, was particularly interested in questions of human conduct, and found much to criticize in current beliefs. But he believed in the possibility of real knowledge (as distinguished from varying personal opinions), if it were sought in the right manner. The method he proposed and pursued was in essence the inductive method. It consisted in checking tentative suggestions by reference to relevant instances until ideas could be formulated in harmony with all the relevant facts. Knowledge appeared to him so important that he identified even virtue with knowledge, namely, a knowledge of what is right. As Socrates left nothing in writing, his general philosophy of life could only be gathered from his own conduct, and this could be variously interpreted by stressing one or other of its several aspects. Aristippus and the Cyrenaics emphasized the cheerfulness of Socrates and his capacity for reasonable enjoyment, and so claimed his weight on the side of hedonism, the view that pleasure is the end and standard of conduct; Antisthenes and the Cynics stressed Socrates' indifference to hardships and his readiness to dispense with comfort when necessary, and so they claimed him as an advocate of the simple life. However, the greatest influence exercised by Socrates on subsequent thought had reference to his method of acquiring knowledge. His emphasis on the supreme importance of developing true *concepts* or ideas was taken up partly by Euclid and the Megarians, but above all by Plato.

Plato (427–360 B.C.) attempted to harmonize the views of Heraclitus, Pythagoras and Socrates. He agreed with Socrates that knowledge is possible, and that it is possible only by means of concepts or general ideas or truths. But he also agreed with Heraclitus that the objects of ordinary observation are an " ever-rolling stream " of changing events, of which no universal truths can be asserted. He therefore concluded that the real objects of knowledge are not the ever-changing things of the world of sense-perception but certain supra-sensible, immutable objects which he named " Ideas," and which he conceived more or less in the manner of the Pythagorean " Forms." The world of sense has but a lower sort of reality and consists of mere " imitations " of, or crude approximations

to, the " Ideas." So he distinguished two types of objects and two kinds of cognition. Real knowledge is concerned with the " Ideas," or with the world of eternal Being; sense-perception is a lower kind of cognition, which he called " opinion," and is concerned with the world of change, or of mere " becoming." Possibly Plato's " Ideas " may have been intended to represent the eternal Laws of Nature. If so, the description of ordinary sense-objects as " imitations " of the " Ideas " was probably intended to bring out the fact that the conformity of ordinary objects and events to natural laws is never precise, only approximate. In any case Plato's conception of the universe was that of an interconnected system, working not merely mechanically but teleologically, that is tending towards cosmic end or purpose—" the Good " towards which the whole creation moves. Allegorically Plato compares " the Good " with the sun. The sun is at once the source of the growth of things and also of the light by which they are seen, so " the Good " is at once the source of all reality and of our knowledge of it. As fountains of personal inspiration no thinkers have surpassed Socrates and Plato, and only very, very few have equalled them. But with regard to calm scientific attitude of mind and scientific and philosophic achievements, the most important thinker of ancient times was probably Aristotle.

Aristotle (384–322 B.C.) was the first to introduce into human knowledge much of that system and articulation which it still retains more or less. His writings are encyclopædic and gather together all the important contributions to human thought up to his time, while his own contributions were colossal. Generally speaking Aristotle was more empirical and realistic than Plato, that is to say, he had more respect for the world of sense, but he was not blind to other aspects of reality, and actually shared some of Plato's fundamental views. Aristotle agreed with Socrates and Plato about the importance of general ideas or concepts for knowledge. But he declined to accept a world of Platonic " Ideas " more or less aloof from the world of sense. He regarded ideas as necessary in order to explain or to understand the world of experience, and he endeavoured to reconcile ideas with percepts, universals with particulars, as jointly constituting the world of reality and of knowledge. His attempt was based on the notions of *matter* and *form*, which had hitherto been divorced from each other, but which he joined in a new harmony. Whereas the early Ionians had stressed *matter* only, while the Pythagoreans and Plato stressed *form* only, Aristotle maintained that they belong to one another, that *form* is immanent in *matter*, the universal is immanent in the particular—they may be distinguished, but not separated from one another. Plato's " Idealism " was largely the outcome of his pre-occupation with pure geometry and its ideal figures. Aristotle's interests were mainly biological, and his study of the phenomena of growth and development gave no encouragement to the conception of immutable " Ideas." In fact by his use of the conceptions " form " and " matter " Aristotle attempted to reconcile the opposite views of those who, like the Eleatics, treated change as illusion and identified the real with the immutable, and those who, like Heraclitus and his followers, identified the real with the " flux " of change or process. Aristotle tried to do justice to both. He recognised in all ordinary things both matter and form,

or a comparatively raw stuff and some finishing touch which made it a comparatively finished product. The nature of the distinction varies in different cases. In the case of a statue the marble is the matter, the shape imposed on it by the sculptor is its form. In the case of a plant, or an animal, or a man, the bodily structure is the matter, while a certain function or combination of functions (nutrition, sensibility or reason, respectively) constitutes the form. In the case of human character certain impulses and instincts constitute the matter, while the way in which they are organised, drilled or " licked into shape," constitutes the form. Moreover, nothing is without some form. Even the most elementary kinds of matter recognized in his time (fire, air, water, earth) were regarded by Aristotle as different forms of primary matter resulting from different combinations of ultimate qualities (dry, moist, hot, cold). Primarily, formless matter was only a limiting conception. Whatever could be regarded as capable of further development was conceived as matter in relation to the process or function, etc., which would develop it further. But even within matter thus conceived one could really recognize something (a form) which distinguished it from a less developed entity. So that the distinction between matter and form is relative. But this relativity has its limits. Material objects cannot have less form than the so-called four elements. Nor can the forms of ordinary things exceed certain levels. A block of granite may assume the form of an image of some kind, but it cannot develop into a plant; an acorn may eventually assume the form of an oak-tree, but not an animal; and so on. Such considerations induced Aristotle to assume the fixity of species, though this did not prevent him from comparing the rich variety of things and noting what a wonderful ascending series, or " scale of nature," they constituted. The conception of such a " scale of nature," beginning with the limiting case of formless matter and ascending through richer and richer forms to the highest forms of life, led him to the conception of an upper limit or apex, a being so perfect that he cannot be regarded as matter for further development, and so could be conceived as form only. This being is God, whom (and whom only) Aristotle conceived in the manner of an immutable Platonic " Idea." God, according to Aristotle, is not the Creator, for matter and the forms are eternal, there being no break in the embodiment of the forms in matter. Yet, in some way, all things feel drawn towards God. He is the object of the world's desire, and by His mere presence lures objects to higher stages of development. He is the " unmoved mover " of the universe, and " it is love [for Him] that makes the world go round."

Intimately connected with Aristotle's doctrine of matter and form is his doctrine of the *four kinds of cause*. If we are to understand certain objects fully, then there are four things we must ascertain, namely, (*a*) their *material cause*, that is, the matter or stuff of which they consist, (*b*) the *formal cause*, that is, the form or law of their constitution or composition, (*c*) the *efficient cause*, that is, the agency through which the matter took on that form, and (*d*) the *final cause*, or the purpose which they serve. Aristotle explained that not all these kinds of causes are to be found or sought in all things; some things are sufficiently explained by reference to the material and efficient causes alone. The physical sciences have

advanced by confining themselves to these two kinds of causes. During many centuries, however, theologically minded thinkers were obsessed with "final causes," to the exclusion of the others. This tendency was intimately connected with the endeavour to prove the existence of God from the evidence of "design," which, it was alleged, could be observed everywhere. The progress of science was seriously hindered by this kind of explanation, which consequently fell into utter disrepute among the pioneers of modern science. But the abuse was contrary to the intentions of Aristotle, who did not look for "final causes" outside the field of biology, where some reference to "final causes" is still felt to be necessary. Aristotle, in fact, had sound views on the necessity of checking speculations by reference to observed facts. In one passage he refers to the necessity of "trusting our senses more than our reasonings, and our reasonings only when the results are in agreement with the facts."

In the history of science Aristotle is famous chiefly for his work in biology, which has elicited an expression of the highest praise from Darwin. The beginnings of scientific biology among the Greeks must be traced at least as far as the medical school of Hippocrates, in the fifth century B.C. Aristotle's father was court-physician to King Philip of Macedonia, to whose son, afterwards Alexander the Great, Aristotle acted for a time as tutor. The origin of Aristotle's interest in biology is thus obvious. It was in some ways a continuation of, though a very great advance on, the Hippocratic tradition. To Hippocrates, or his school, it may be pointed out incidentally, is due the doctrine of the "four humours," which to some extent still survives in popular thought and speech. According to this doctrine there are four kinds of "humour" (or juice) in the human body, namely, blood, phlegm, yellow bile, and black bile, and the temperament of each individual is determined by the preponderance of one of these "humours" over the others. There are thus four kinds of temperament, namely, the sanguine, the phlegmatic, the choleric, and the melancholic temperament, corresponding to the preponderance respectively of one of the four humours as enumerated above.

Aristotle's biological work was continued, in the field of botany, by his successor Theophrastus (370–285 B.C.). Otherwise very little original research was carried out in biology for many centuries afterwards.

Post-Aristotelian Thinkers

Greek philosophy continued for several centuries after Aristotle. But already in Aristotle's lifetime a certain change of spirit came over it. This was the result of the loss of Greek independence after the battle of Chæronea in 338 B.C. The troubles caused by the ascendancy of Macedonia left little inclination for pure philosophy. What people needed was some kind of moral or religious tonic. Accordingly, post-Aristotelian philosophy is predominantly ethical or religious in character. The Stoics, the Epicureans, and the Sceptics were all interested mainly in the moral problems of life, and in the last resort they all commended the same kind of ideal of conduct, namely, the cultivation of equanimity or peace of mind, and self-emancipation from the bondage of external

circumstances. Apart from their ethical doctrines, the Epicureans are chiefly noteworthy for having embraced the atomic theory, the Stoics for their pantheism and cosmopolitanism, and the Sceptics for their anticipation of nearly all the important arguments subsequently employed by defenders of philosophic or religious doubt. The survival of Epicureanism for many centuries was chiefly due to its atomism; indeed, it was the Roman Epicurean, Lucretius (98–55 B.C.), whose poem *On the Nature of Things* gave classic expression to the atomic theory of antiquity.

Stoic pantheism, though partly a continuation of the philosophy of Xenophanes, was probably in part also among the first fruits of the new contact between Greeks and Orientals in Alexandria, which was founded by Alexander the Great, in 332 B.C., and eventually became the most important seat of science and philosophy in ancient times. The Stoics modified Aristotle's doctrine of matter and form into a doctrine of body and soul, and they conceived the universe as an organic whole having both a body and a soul. All finite things were treated as but parts of the "One and All," which was regarded at once as Nature and God, as Destiny and Providence. Nature was thus conceived as inspired by universal reason, and could readily be regarded as worthy of human imitation. Hence the Stoic ideal of "life according to nature." As a corollary to their pantheism they pleaded for universal brotherhood. "All men [said Epictetus] are brethren, and God is the Father of all."

The influence of the East is more marked in that blend of philosophy and religion known as Neo-Platonism. The system of Greek philosophy which had the strongest leaning towards religion was that of Plato. Platonism accordingly served as a link between Western philosophy and Eastern religion when the two came into close contact in Alexandria. The most famous of the early Neo-Platonists was Philo Judæus of Alexandria (*c.* 25 B.C.–A.D. 50), who attempted to harmonize Hebraism and Platonism. To this end he interpreted the Bible allegorically, and identified the Platonic "Ideas" with Spirits mediating between God and man. The allegorical method proved too cumbrous, and Neo-Platonism owed its success mainly to Plotinus (204–270) and Proclus (410–485).

In the realm of science the Alexandrians made considerable advances, especially in mathematics, pure and applied. The ground had been prepared for them to some extent. The Egyptians and Babylonians already had made considerable progress in the art of calculation and mensuration. The earliest extant mathematical treatise is an Egyptian papyrus (now in the British Museum, and named the Rhind Papyrus after its donor) copied about 1600 B.C. from a much older original. From this it is clear that the Egyptians could manipulate large figures, measure land, estimate the contents of barns, etc., at an early date. So could the Babylonians. But the Greeks took up these studies in a more scientific spirit, formulating and proving general theorems instead of dealing only with concrete instances. Thales, Pythagoras, Hippocrates (not the father of scientific medicine), Plato, Eudoxus, Aristotle and others contributed to the development of Geometry, which Euclid of Alexandria (330–275 B.C.) systematized in his classical "Elements," which remained *the* class book of geometry for more than two thousand years. Other Alexandrians, notably Aristarchus, Archimedes, Apollonius, Hipparchus, Ptolemy, Pappus,

Diophantus, Proclus, and others carried mathematical studies some stages further, especially in connection with its application to astronomy, optics, mechanics and engineering.

The Alexandrians also made important contributions to Astronomy. Here likewise the ground had been well prepared. Long before the Greek period the Babylonians, and more especially the Chaldeans, paid close attention to the heavenly bodies. Their motives were mainly religious and astrological, but they accumulated much valuable information all the same, and many of our Western ideas and practices are derived from them. It was they who first observed the seven planets and associated them with a seven-day week, each day being called after one of the planets, and divided into twenty-four hours. They also divided the zodiac into twelve divisions or constellations, and associated them with the twelve lunar months. They were the first to discover that the evening star and the morning star were the same. And they instituted a system of regular astronomical observations, under the direction of Astronomers-Royal, thousands of years before such things were thought of in the West. Indeed, one of their records of a solar eclipse in the year 1062 B.C. was actually made use of, in recent years, by the astronomer Cowell in order to rectify the lunar theory. As the result of their long and regular astronomical observations, the Babylonians acquired already in early times an accurate knowledge of the periods taken by the sun, moon, and the other five planets then known, to complete their orbits, and so could foretell the position of each among the stars, and predict the occurrence of solar and lunar eclipses. But they regarded heaven as a solid stationary vault and the earth as a stationary mountain round which the stars moved, and in whose hollow part was the abode of the dead. Some of their ideas were taken over by the Greeks as well as by the Egyptians. The belief in a stationary, and usually a flat, earth survived for a long time even among the Greeks. Anaximander, however, already rejected the belief that the earth rests on a base of indefinite depth. He maintained that the earth floats free in space, and that the sun, when it sets in the west, continues to move to the other side of the earth. Anaxagoras (500–428 B.C.) gave the correct explanation of eclipses, the phases of the moon, and partly also of the Milky Way. Some of the Pythagoreans, moreover, conceived the earth to be a sphere, in fact a kind of star moving like the sun, moon, etc., round a fire placed at the centre of the universe. This was the first rejection of the geocentric theory, but did not yet amount to a heliocentric theory. It was Aristarchus (310–230 B.C.) who first proposed the hypothesis that the sun is the fixed centre round which the earth moves in a circular orbit while rotating at the same time about its own axis. But the heliocentric theory did not gain acceptance until it was revived by Copernicus nearly eighteen centuries later, and only very gradually even then. In the meantime various Greek astronomers attempted to determine the geometry of astronomical phenomena on the basis of a geocentric theory, and on the assumption that all heavenly bodies move in orbits which are either circular or are compounded of circular motions. The greatest mathematical ingenuity was displayed in various attempts "to save appearances" in celestial phenomena. Among the most familiar devices employed were those of concentric spheres with axes of varying

directions; epicycles, or circular orbits round a centre which is itself moving in a circle; and eccentrics, or circular orbits whose centre is at some distance from the earth. By all these devices it was attempted to retain the belief in the circular orbits of the heavenly bodies in spite of their apparent irregularities. The whole of Greek astronomy was systematized by the Alexandrian Ptolemy (second century A.D.), whose treatise *Syntaxis* (also known as *Almagest*) remained the standard work on astronomy until the time of Copernicus and even later.

Turning next to the science of Mechanics, it is obvious from the buildings constructed by the Babylonians and Egyptians (their palaces, temples and pyramids) that practical mechanics had made great advances long before the Greek period. But into this study likewise the Greeks were apparently the first to introduce a scientific spirit. The foundations of this science appear to have been laid by Aristotle, who propounded some of the fundamental principles of the subject, though he did not express them very happily. The most important contributions to the science were made by Alexandrians, and especially by Archimedes (287–212 B.C.). He formulated correctly the principles of the lever, of the pulley, and of the centre of gravity of bodies. He discovered the principles of specific gravity, and of the equilibrium of floating bodies. And his inventions include the water-screw for raising water. The work of Archimedes was continued to some extent by other Alexandrians, notably by Ctesibius and Hero, whose energies, however, were mainly directed to the construction of apparently wonder-working inventions.

Chemistry, too, was actively studied by the Alexandrians. In ancient Egypt, it had been a secret art practised by priestly adepts and largely empirical in nature; in Greece philosophers and craftsmen lived in different worlds; but in Alexandria the practical knowledge which had been handed down from ancient Egypt came into active contact with Greek thought, and in this fusion of practice and theory the science of chemistry had its beginning. The Alexandrian chemists, observing that matter underwent many remarkable changes, concluded that it was transmutable. Their theory of matter was thus like that of Aristotle, but was supported to some extent by experiment. The influence of the Neo-Platonists ultimately caused Alexandrian chemistry to become mystical and to encourage the belief in the "philosopher's stone," which was alleged to turn base metals into gold or silver, and in the "elixir" or "panacea," which was supposed to cure all diseases. Their writings abound in signs and symbols, used to preserve secrecy, the breach of which was punished with death. Their experimental results were too slight to support their far-reaching theories.

In 47 B.C. the Romans took possession of Alexandria, and its glory began to decline. The Romans had a genius for all things connected with imperialism, notably for law, administration, and engineering. But pure science did not appeal to them. Yet the annals of the history of science and philosophy contain some Roman names of distinction. The most important of these must be mentioned. Cicero (106–43 B.C.) had a masterly knowledge of the philosophical systems of his predecessors, and his writings did much to keep alive some interest in philosophy during the dark centuries that were to follow. Lucretius (98–55 B.C.) has already been

referred to as the classical exponent of the atomic theory of antiquity. Vitruvius (flourished about 14 B.C.) wrote the best ancient work on architecture and building (*De Architectura*). Strabo (*c.* 60 B.C.–A.D. 24) was an eminent traveller and geographer. Pliny the Elder (A.D. 23–79) wrote a famous *Natural History* in which some 20,000 topics are discussed, and nearly all the knowledge of antiquity, and many of its superstitions, are collected. Frontinus (A.D. 40–103), at one time Roman Governor of Britain, was the author of a notable work on *The Waterworks of Rome*. The Emperor Marcus Aurelius (A.D. 121–180) was a philosopher of distinction, and perhaps the most famous Stoic. His court physician Galen (*c.* A.D. 130–200), a native of Asia, but a Roman by adoption, was next to Hippocrates probably the most renowned doctor of antiquity, and his works served as a Doctors' Bible for many centuries. Lastly, Boethius (480–524) was the author of the widely read *Consolations of Philosophy*, and his various works served, for many centuries, as repositories of the rudiments of a liberal education.

In the meantime Christianity had come on the scene and grown powerful. Its gospel was a gospel for the lowly, and it was rather hostile towards the "high-brow." Of philosophy and science it was frankly contemptuous, and some of the Apostolic Fathers, like Tertullian, not only did not mind being unphilosophical in their faith, but seemed rather proud of it. In defence against hostile critics, however, it was found advisable to employ a certain amount of philosophical argument, and so the apologetic literature of the Patristic period is tinged with a certain amount of Platonic or Neo-Platonic doctrine like that of the "Logos." Moreover, some of the early Fathers, notably St. Augustine (A.D. 354–430), had been thinking pagans before they became believing Christians, and could not entirely abandon their philosophic interests. But the general attitude of the Christian Church towards philosophy and science was decidedly hostile. In 390 Bishop Theophilus destroyed one of the libraries of Alexandria. In 415 Hypatia, the daughter of Theon the astronomer, and herself a teacher of mathematics, was brutally murdered in Alexandria by a mob of Christian fanatics. And to crown it all the Emperor Justinian had all schools of philosophy closed in 529. The first great period in the history of human thought thus came to an end, leaving the West to darkness and the Church.

THE MIDDLE AGES

Moslem Philosophers

When the Athenian schools of philosophy were closed by Justinian, many of the teachers migrated to Syria and Persia, where they were safe from Christian persecution. Their advent there stimulated a certain amount of interest in philosophy and science, which was considerably intensified in the next century when Alexandria was captured by the Arabs (641). By 711 Islam had swept through Arabia, Syria and Mesopotamia, on the one hand, and along the north coast of Africa, as far as the Straits of Gibraltar, on the other. From here the Moors (that is, the Arabs of Mauretania or North Africa) crossed over into Spain. In this way philosophy and science found their way back to Europe through Moslem channels.

The most important Moslem philosophers were Al Kindi (d. 870), Alfarabi (d. 950), Avicenna (980–1037), and Averroes (1126–1198). Of these the first three lived in Bagdad, the last in Cordova. They knew most of the works of Aristotle, and some of the works of Plato. Their philosophy was Aristotelianism tinged with Platonism. It is interesting to note that Avicenna first gave prominence to the question of the relation between the universal and the particulars subsumed under it. This problem soon became the bone of contention among the Scholastics, whose ranks it divided into Nominalists and Realists, according as they regarded universals as mere names, and particulars as the only realities, or held that universals had an existence of their own apart from the particulars. The most influential, and most Aristotelian, of these Moslem thinkers was Averroes. According to him there is a perfect, eternal world beyond the stars, besides our sub-lunar world of imperfection and change. Matter is eternal and contains seminal " forms " which transform it into its final states under the influence of higher " forms " (or " intelligences ") or, in the last resort, of God. The soul of man is inseparable from his brain, and perishes with it. But the Reason that dwells in man is immortal. By cultivating this Reason, man may enter into union with the universal and eternal " Active Reason." The popularity of Averroes' commentaries on Aristotle is attested by the fact that the Schoolmen afterwards referred to him as " *the* commentator," just as they called Aristotle " *the* philosopher."

Jewish Philosophers

Side by side with the Moslem philosophers there were a number of Jewish thinkers who likewise helped to keep philosophy alive, or even to develop it to some extent, and who in due course mediated between Islam and Christendom when the latter was ready to resume an interest in philosophic problems. From early times some Jews took an interest in philosophy. Traces of this are to be found in the Bible already. In Alexandria there appears to have been a whole school of Jewish philosophers, whose influence may be traced in the Greek translation of the Bible (the Septuagint) and in the Sibylline Oracles. Mention has already been made of Philo Judæus, the best known among them. This interest in philosophy was revived when the Jews were living under favourable conditions in Moslem centres of culture like Bagdad and Cairo, Cordova and Toledo. They maintained a friendly rivalry with their learned neighbours. Almost every school of Moslem (or Græco-Moslem) thought found its parallel in contemporary Jewish thought—Platonism and Aristotelianism, traditionalism and modernism, dogmatism and rationalism, fatalism and voluntarism. The leading Jewish thinkers of this period were Israeli (between 850 and 950), Saadyah (892–942), Bachyah (*c.*1000–1050), Ibn Gabirol (*c.*1020–1070), Maimonides (1135–1204), Gersonides (1288–1344), and Crescas (1340–1410). The Jewish philosophers played no small part in the subsequent renascence of philosophy in Christendom. They helped with the Latin translation of Greek and Arabic treatises on philosophy, and they influenced the thought of the leading Scholastics. Gabirol's *Fountain of Life* helped to mould the thought of Duns Scotus, among others; and Maimonides' *Guide of the Perplexed* influenced

Albertus Magnus and Thomas Aquinas, among others. Maimonides and Crescas also had a share in the shaping of the philosophy of Spinoza.

The Scholastics

The revival of Christian interest in philosophy may be traced to some extent to the beneficent results of the educational work of Charles the Great, who founded schools throughout France in the eighth century. The subjects gradually introduced into these schools consisted of the so-called "seven liberal arts," namely, grammar, logic, rhetoric, arithmetic, geometry, astronomy, and music. The teachers who taught them were known as *doctores scholastici*. When in the course of the eleventh and twelfth centuries the new Universities of Paris, Bologna, Salerno, Oxford and Cambridge were founded, the name *Scholastics* (or Schoolmen) was extended to all who taught philosophy and theology there. The main motive of the Scholastics was to reconcile Christian theology with philosophy. The early Scholastics, John Scotus Erigena (810–877), Roscellinus (*c.*1051–1121), St. Anselm (1033–1109), and Abelard (1079–1142) inclined towards Platonism. In the course of the thirteenth century, however, as the works of Aristotle became better known, his philosophy grew in favour in the Church, especially with the Dominican order, which turned out the two most eminent Aristotelian Schoolmen, Albertus Magnus (1103–1280) and St. Thomas Aquinas (1225–1274). Albertus Magnus appears to have been the first to draw the line between *natural* knowledge and *theological* knowledge, that is to say, between the light of reason and the light of revelation. This distinction, though objectionable in some ways as implying a breach in the unity of the universe, served for a long time the very useful purpose of securing some measure of freedom for philosophy and science, which the Middle Ages were only too prone to treat as mere handmaids to theology or the Church (the realm of grace as distinct from the realm of nature). St. Thomas Aquinas stressed the Aristotelian distinction between matter and form, but went far beyond Aristotle as regards the number of "forms" to which he attributed an existence independent of matter. The human soul, though associated for a time with a body, is, according to Aquinas, capable of separate existence. And Aquinas postulated a whole scale of such "separate forms," beginning with the human soul, passing through a whole hierarchy of angels and spirits (some of which guide the stars in their courses) and culminating in God, who is the "Absolute Form." By his doctrine that God had endowed nature with a certain amount of autonomy, Aquinas supported the tendency, initiated by Albertus Magnus, to allow philosophy and science (that is, "natural" knowledge) some measure of autonomy. This tendency was further encouraged by Aquinas's theory of Knowledge. For whereas St. Augustine had treated all knowledge as the result of divine illumination, Aquinas regarded it as partly the product of images produced in the soul by external objects, and thus allowed some importance to the empirical study of natural phenomena. He held that material objects *qua* particular objects become known through the senses, but their "forms" become known through the intellect.

The Franciscan order showed great hostility to the Aristotelianism of the Dominicans. Their principal spokesmen, Duns Scotus (1265–1308) and William of Occam (d. 1349), repudiated any attempt to harmonize theology with philosophy, or faith with natural knowledge. What is true for natural knowledge (that is, for science and philosophy) may be quite false in theology, and theology is supreme. They repudiated the intellectualism of Aquinas, and laid stress on the will as the fundamental faculty of the soul. The good is placed above the true, and the good is whatever God has arbitrarily decreed. God has not decreed certain things because they are intrinsically good; rather they are good only because He has decreed them. And it is man's duty to obey God. Even so-called evil deeds are good if they are done in the service of God. As the decrees of God are made known by the Church, all that was thus claimed for God was really claimed for the Church, whose authority and power were supreme throughout the Middle Ages, and more or less effectively repressed all freedom of thought.

Mediæval Science

The story of science in the Middle Ages is naturally very similar to that of philosophy. Such contributions as were made to the survival and development of science were due mainly to the Orientals, touched mostly by the spirit of the ancient Greeks. In the seventh century our system of numerals was discovered or invented in India. Its importance can hardly be exaggerated. About 900 it was adopted by the Arabs, who introduced it into Europe, where it first came into vogue about 1200. In the ninth century the Arabs also took in hand translations of the most important Greek works on science. In due course they had Arabic versions of the medical works of Galen, Euclid's *Elements* of geometry, and Ptolemy's astronomical masterpiece, known as *Almagest*, from the Arabic version. Acquaintance with these and other scientific treatises stimulated Moslem interest in science. Al Batani, in the latter part of the ninth century, carried on fruitful work in his observatory at Antioch, recalculating the precession of the equinoxes and preparing new astronomical tables; and about a century later Ibn Yunus made important contributions to the study of solar and lunar eclipses. The Moslems built a number of observatories, including the one at Seville, which was the first European observatory. In medicine Rhazes of Baghdad (tenth century) and the philosopher Avicenna did work of distinction. Avicenna's *Canon* was used as a textbook of medicine in various European Universities till late in the seventeenth century. In physics Ibn-al-Haithan (965–1020) carried out valuable experimental work in optics. Al Biruni (973–1048) determined the specific gravity of precious stones, and carried out various geodetic measurements. He and Omar Khayyám, the poet, also wrote treatises on mathematics. But of all the sciences chemistry perhaps owes most to the Arabs. The best known of their chemists was Jabir, who is sometimes called the father of scientific chemistry. He lived in the eighth century most probably, but is sometimes identified with, and sometimes distinguished from, a certain Geber, who may have lived later. His great merit was his insistence on actual observation, as distinguished from hearsay

and book-lore. He carried out many experiments in distillation, filtration, sublimation, and calcination. He gave careful accounts of these chemical processes, and appears to have been the first to notice that metals heated in an open vessel gain in weight. His name is especially associated with a new conception of metals, namely, that they are all the products of sulphur and mercury combined in different proportions, and that, inasmuch as they have the same constituents, they can be transmuted one into another. In the subsequent history of mediæval chemistry these ideas played a great rôle. Transmutation of base metals into precious ones was a common quest; and the " principles " of sulphur and mercury (to which, later on, salt was added) took their place beside the " four elements " of earlier thought. Another famous Moslem chemist was the above-mentioned Rhazes. He was more systematic than Jabir, and made an attempt at an elaborate classification of chemical substances. First he classified them into the familiar three classes, animals, vegetables, minerals, and then subdivided each of these into a number of sub-classes. He also gave a full account of the apparatus needed in the study of chemistry. Like Jabir, he believed in transmutation. Apparently the philosopher Avicenna was one of the few mediæval thinkers who rejected the possibility of transmuting metals. But there was a whole succession of Moslem chemists who were really scientific. The debt of subsequent European science to the Arabs is evidenced by the number of Arabic expressions which gained currency in other languages—alchemy, alembic, algebra, azure, elixir, zenith, zero, etc. It is also shown by the fact that when Roger Bacon commenced his crusade in favour of scientific research, he attached great importance to the study of Arabic and Hebrew, as well as Greek, as a means of access to the scientific knowledge already accumulated.

Perhaps the chief stumbling-block in the way of mediæval thought consisted of certain distortions of Platonic and Aristotelian doctrines. In his *Timæus* Plato had suggested that the great world (the macrocosm) is really alive, and that man is in some ways a small model of it (microcosm). This was developed in the Middle Ages into extravagant attempts to correlate parts of the great world (the planets, etc.) with parts of the microcosm (parts and organs of the human body). This ended in weird astrological and mystical fancies. Aristotle's doctrine of " forms " was similarly distorted or even more so. The Neo-Platonists and even some of the Aristotelians (see, *e.g.*, the above account of St. Thomas Aquinas p. 18) identified the " forms " of things with their " souls " or " spirits." This encouraged the mystical treatment of " forms " as occult powers which might accomplish anything, and which could therefore be conveniently resorted to to explain everything. In this way " forms," " occult powers," and " principles " helped to build up a pseudo-science which stood in the way of genuine, empirical science. Much of the time and energy of the pioneers of modern science (see, *e.g.*, Robert Boyle's *Sceptical Chymist*) was taken up in exorcising these spirits.

Transition

Even the Middle Ages, however, had quite a number of searchers who were imbued with the true spirit of science. So far as Christendom is

concerned, the two most famous men of this type were Roger Bacon (*c.*1214–1292) and Leonardo da Vinci (1451–1519). Bacon appears to have obtained most of his ideas from Arabic, Greek, and Hebrew sources, but, though not entirely free from mediæval fancies, caught the scientific spirit, and did his best to apply it himself and to persuade others to use the scientific methods of observation, experiment and verification, instead of relying on books and other authorities. His works were condemned by the general of the Franciscan order, to which he belonged. He therefore had little opportunity of exercising much influence. Da Vinci was a universal genius, whose influence might have been great enough to inaugurate the modern revival of science about a century earlier than its actual commencement. But, for reasons not difficult to surmise, he refrained from publishing his scientific researches.

The Renaissance and the Reformation, as such, afforded no direct help to the revival of either philosophy or science. The Renaissance, with its predominant interest in classical literature as such, gave no direct encouragement to a first-hand study of nature. Indeed, classical learning obtained such a hold on the Universities that these showed little love for science, and new societies (like the Royal Society, for example) had to be started for the encouragement of experimental science. Indirectly, however, the Renaissance helped to shake Europe out of its authoritarian torpor by acquainting people with the freer, more naturalistic spirit of the classical age, which the invention of the printing press (1455) helped to propagate. As to the Reformation, the reformers were just as intolerant as the Catholic Church, if not more so. Indirectly, however, the squabbles of the Churches had the effect of turning some of the best minds away and setting them on the path of a quest after truth independently of the rival Churches and the authority which they all claimed.

The most obvious feature of mediæval thought was its subordination to authority—the authority of the Church, in the first instance, and of such books as the Church favoured. As the Church encouraged little interest in this world, and stood primarily for supernaturalism, it had helped to reinstate something very like the mythological age which had preceded the birth of science and philosophy. The revival of science which marked the beginning of the modern period was concurrent with the revival of naturalism and the gradual repression of supernaturalism. The growth of interest in natural phenomena as such, and of the habit of direct observation of them, instead of accepting the accounts of authorities, was slow. Still, the idea was on the march. Some of the milestones may be indicated as follows. Lorenzo Valla (1408–1457) openly attacked Scholasticism for its interest in words instead of in things. Nicolaus Cusanus (1401–1464) showed scientific leanings, and openly accepted the view that the earth is spherical and rotates about its axis. The voyages of discovery in the fifteenth and sixteenth centuries (Columbus, Vasco da Gama, Magalhaes) helped to spread this view, and widened people's outlook. Paracelsus (1493–1541) and Van Helmont (1577–1644) denounced authority and book-lore in the study of nature. Telesio (1508–1588) founded an academy in Naples for the empirical study of natural phenomena. The martyrdom of Servetus in 1553, and of Giordano Bruno in 1600, helped to make manifest the hostility of the Churches (Reformed

as well as Catholic) towards the naturalist spirit of science. Montaigne (1533–1592) and Sanchez (1562–1632) met dogmatism with scepticism, and advanced the cause of toleration. Francis Bacon (1561–1626) summed up all the faults of mediævalism. His persuasive pen and important position did much to prepare the way for the new scientific age, of which he proclaimed himself the herald. But most effective of all was probably the work of Copernicus (1473–1543). Slowly but steadily his book *On the Revolution of the Celestial Orbits* (1543) induced thoughtful people to abandon the geocentric theory of the universe. And when the earth was once relegated from the position of cosmic centre to that of a minor planet of the sun, it was felt to be impossible to continue to regard man as the crown of creation, or as the hero of the whole cosmic drama; so Church mythology was shaken to its foundations. In a more modest, yet positive and valuable, manner, Vesalius (1515–1564) likewise contributed to the new birth of science. His book on *The Structure of the Human Body* (published in the same year as Copernicus' revolutionary treatise) set a good example of a sober, objective study of man based on direct observation, instead of on authorities, and refraining from all speculations about alleged correlations between the planets, etc., and the parts and organs of the body, between the macrocosm and the microcosm. Supernaturalism, the great enemy of science, was being steadily excluded from the study of natural phenomena. The spirit of modern science had arrived.

MODERN TIMES

The advance of science, in modern as in ancient times, meant an extension of the realm of natural knowledge and the steady repression of the claims of the supernatural. The work of science consists essentially in the discovery of order among the phenomena of nature. It seeks to formulate the laws inherent in natural events, and to account for them without recourse to whatever is merely magical or mysterious, mythological or supernatural. But the human mind is so deeply attached to myth and wonder that some of the greatest pioneers of modern thought could not entirely emancipate themselves from the bonds of the supernatural, and their successors have repeatedly succumbed to its lures. Compromise between the two loyalties has been, and still is, rather common. And the commonest type of compromise resorted to consisted in being strictly scientific on weekdays and supernaturalist on Sundays, or scientific in writing on astronomy, physics, chemistry, etc., and supernaturalist when writing on philosophical and religious subjects. Still, not all suffered from such divided personality, and even those who did advanced, in spite of themselves, the great cause of natural knowledge.

Seventeenth Century Science

The most impressive movement with which modern thought began is probably to be found in that steady, irresistible, almost fate-like march of astronomy from Copernicus to Newton. The final outcome of this development was vastly to reduce the traditional differences between heaven and earth. On the one hand, the earth ceased to be regarded as the

central stage of the cosmic drama; on the other hand, the celestial bodies, once conceived to be composed of a special kind of element (quintessence) and deified by many (even by Kepler!), were shown to be subject to the same material conditions (especially gravitation) as the earth. In the eyes of some people, at all events, all this tended to thrust the supernatural out of ken. Hence the stubborn resistance with which the Churches opposed the relentless march of the new astronomy with its implicit naturalism.

Galileo (1564–1642) probably deserves the chief credit for the great step forward in the emancipation of science from mystification. Copernicus died soon after his book was printed, and the book itself was put on the Index. But for Galileo's whole-hearted (if slightly disguised) championship of the Copernican theory, its day would have been long delayed. His own important discoveries added enormously to the momentum of the whole movement. His telescope revealed the earthy appearance of the moon with its mountains and valleys, and the spots on the sun, thus shattering traditional beliefs in the perfection of celestial bodies. His observation of Jupiter and its satellites furnished a striking parallel to the solar system as represented by the Copernican theory. Moreover, by his conception of inertia he succeeded in explaining away most of the difficulties which appeared to stand in the way of the Copernican theory.

Tycho Brahe (1546–1601) had in the meantime made the most important advance in the accuracy and number of his astronomical observations. His work set a most valuable example of ingenuity in the construction of scientific instruments, of patient devotion to the closest and continuous observation of phenomena, and admirable restraint in letting speculation wait for an adequate accumulation of data. By way of compromise between the heliocentric and geocentric theories he suggested the possibility that the sun and the moon move round the earth, while the other planets move around the sun. This view may have served as a halfway house for some people, until they could go all the way.

Kepler (1571–1630) offers a remarkable instance of a mathematical enthusiast and mystic converted gradually into a sober scientist. Embracing the heliocentric theory he went into ecstasies about the Sun, calling it God the Father. And he was almost beside himself when he thought he had discovered a correlation between the orbits of the planets and the five regular solids—a correlation to which he at first ascribed great mystical significance. But persistent work in science sobered him, and led him to such important real discoveries as made him the immediate forerunner of Newton. Kepler was acting as Tycho Brahe's assistant when Tycho died. Kepler received Tycho's vast collection of data, and set about the task of interpreting them. The main result of his life's labours consisted in the formulation of the famous three Laws of Kepler. They are the following. (1) The planets move in elliptic orbits having the sun in one focus. (2) A planet moves not uniformly but in such a way that the straight line joining its centre to that of the sun (the radius vector) sweeps out in its orbit equal areas in equal times. (3) The squares of the times which the several planets take to complete their orbits are proportional to the cubes of their mean distances from the sun. Kepler not only dealt with the geometrical and temporal aspects of planetary motion, but for

the first time in the history of human thought he attempted to give an account of the mechanics of the movements of the planets. Influenced by the work of Gilbert on magnetism, and his proof that the earth is a huge magnet, Kepler suggested that the sun emits lines of magnetic force which act tangentially on the planets and keep them moving in their elliptic orbits.

What with Galileo's three laws of motion and other discoveries, Kepler's three laws of planetary movement and Descartes' new mathematical methods (Analytical Geometry), the materials were prepared for the first great synthesis of physical phenomena. For the time being all these discoveries, important as they were, seemed to be entirely disconnected, and to have no obvious bearing on one another. It needed the penetrating eyes of a synoptic genius to see the single system of which they all formed so many aspects. Fortunately for the history of science the hour produced the man.

Newton (1642–1727) was born in the year in which Galileo died, and was the first to appreciate fully the significance of Galileo's three laws of motion, which in due course gained universal acceptance in the formulations which Newton gave them. Now the chief novelty of the new astronomy was the attempt to explain the mechanics of planetary movement, all the astronomers up to the time of Kepler having confined their attention to the geometry (that is, the precise shape of the orbits) of the motions of the planets. Of course even as regards this geometrical problem, Kepler's laws marked an advance of the utmost importance, but his attempt at a planetary mechanics, though a hopeless failure, was an entirely new departure. His example in this respect was followed by Descartes, who suggested the rival hypothesis of vortices, or enormous whirlpools, for the conveyance of the planets along their orbits. Now Newton was greatly drawn by the mechanical problems of astronomy, but his firm grasp of Galileo's first law of motion (namely, if no force acts on a body in motion, it continues to move uniformly in a straight line) convinced him that Kepler was on the wrong track, because he assumed that some force was required to *maintain* a body in motion, whereas Galileo had shown that force was only necessary to *change* its motion. What really needed explanation was not the continued motion of the planets, but only their deviation from a straight path. What causes the *curvature* of the orbits? Newton concluded that there must be some centripetal force which pulls the planets towards the sun. Such a centripetal force would account for the transformation of an initial straight path into a curved one. Now the intensity of a force emanating from a centre would naturally vary inversely with the square of the distance from the centre, because the force radiates or gets dissipated into larger and larger spheres, and the surface of a sphere varies with the square of its radius. But, as Newton showed, movement in an elliptic orbit implies an inverse square law. Thus the assumption of a centripetal force situated in the sun would account for the elliptical orbit of the planets, which Kepler's first law formulated merely as a brute fact. The same assumption, moreover, would account also for Kepler's second and third laws. The next thing to ascertain, if possible, was the nature of this centripetal force. According to the familiar legend, which ought to be true if it is not, it occurred to

Newton, while he was watching the fall of an apple, that the force which pulls the moon towards the earth, and the earth and the other planets towards the sun, might be the same force as that which pulls the apple to the ground, namely, gravity. And his calculations eventually led him to formulate the Universal Principle of Gravitation, namely, that every particle of matter attracts every other particle of matter with a force varying directly as the mass and inversely as the square of the distance.

The Law of Gravitation was the most comprehensive discovery that had yet been made, and retained its hold for several centuries. In one grand generalization it embraced all the physical phenomena of the universe, explaining such diverse phenomena as the fall of an apple, the movements of the tides, the shape of the earth, the motion of the moon round the earth, of the Medicean stars round Jupiter, of the earth, Jupiter and the other planets round the sun, and even the apparently erratic movements of comets, etc. Naturalism had achieved a great triumph, and repudiated the necessity of drawing any hard and fast line between terrestrial and celestial phenomena.

Although the astronomical advance of the seventeenth century almost overshadows all its other scientific discoveries, it made, of course, other important contributions to science. At least some of these must be indicated here.

In one form or another the atomic theory was revived. Descartes, indeed, had a theory of infinitely divisible matter not inherently mobile, which was very different from the atomic theory of the ancients. But Gassendi (1592–1655), Boyle (1627–1691), and Newton embraced the old atomic theory in its essentials, with the metaphysical reservation that the atoms were created by God and endowed by Him with motion and their other properties. For the time being the main significance of this "corpuscularian philosophy," as Boyle called it, lay in the fact that it helped to displace the traditional " four elements " and " three principles " (*tria prima*) and the " forms " and " occult qualities " which obstructed the path of scientific chemistry. Boyle, indeed, confessed that he could not see " how from matter, barely put in motion, and then left to itself, there could emerge such curious fabricks as the bodies of men and perfect animals, and such yet more admirably contrived parcels of matter as the seeds of living creatures." He therefore assumed an " architectonick principle or power " to account for it. The problems of vitalism and biochemistry, however, did not become urgent for a long while yet. And in the meantime inorganic chemistry could advance unimpeded.

So far as biology was concerned, the most important contribution of the seventeenth century was Harvey's discovery and experimental proof of the circulation of the blood. Descartes, indeed, attempted to treat the lower animals and even the human body as automata, and to describe all their physical activities mechanically. But his adherence to Galen's doctrine of animal and vital spirits, with their somewhat ambiguous position between physical and mental entities, seemed to open a back door for occult or quasi-occult influences. Harvey's discovery of the circulation of the blood, and his account of it in more or less purely mechanical terms, helped to put biology on a naturalistic basis.

In physics the most important discoveries related to optics. Snell

discovered his law of refraction in 1621. Descartes tried to explain all the phenomena of light on the analogy of the mechanics of moving particles. Roemer discovered the velocity of light in 1676. Newton made his classical experiments on the composite character of white light. And Huygens formulated the undulatory theory of light, which was destined to have such far-reaching consequences in the nineteenth century.

But perhaps most promising, in some ways, were certain important aids which the seventeenth century created for the subsequent advance of science. First of all there were certain advances in mathematics—the most potent intellectual tool of science. Napier invented logarithms. Descartes invented Analytic Geometry. Pascal (1623–1662) formulated the mathematical theory of Probability. Lastly, Leibniz and Newton invented the Infinitesimal Calculus, which provided the basis for nearly all subsequent discoveries in mathematics. Next to the intellectual tools must be mentioned the invention of certain material instruments which rendered possible that fruitful observation and experiment, and that accurate measurement of phenomena, on which science is based. The telescope was invented by a Dutch spectacle-maker at the beginning of the seventeenth century. Its adjunct, the micrometer, was constructed by Gascoigne about 1639. The microscope was invented about the same time. Guericke (1602–1686) invented and Boyle improved the air-pump. The thermometer was invented by Galileo, and improved by the members of the Accademia del Cimento, who introduced the method of hermetically sealing it, and by Renaldini, who in 1694 showed how the melting point of ice and the boiling point of water might be used as fixed points for a thermometric scale. Torricelli (1608–1647) invented the barometer in 1643, and Pascal demonstrated its accuracy, and so laid the ghost of the old superstition about nature's abhorrence of a vacuum, by which the action of pumps used to be explained. Huygens invented the pendulum clock. Finally, mention must also be made of the foundation of various academies which were formed for the express purpose of promoting scientific research. Rome had the Accademia dei Lincei. In Florence the Accademia del Cimento was founded in 1651. The Royal Society of London received its charter in 1662, though its beginnings go back to 1645. And the French Académie des Sciences was founded in 1666.

Seventeenth Century Philosophy

The differentiation between science and philosophy came into vogue only gradually, and largely in consequence of Newton's distinction between scientific inferences drawn direct from observations and metaphysical " hypotheses " which went beyond, and in which he declined to indulge in his capacity of astronomer and physicist. In the seventeenth century the line between science and philosophy was still very fluid, though there was a tendency to mark off the sciences as " natural " philosophy from the rest of philosophic thought. If it is not altogether easy to draw the line between mediæval and modern science, it is even less easy to draw the line between mediæval and modern philosophy, using the term philosophy in the later and more restricted sense of the term

(*i.e.* as exclusive of the sciences). But we may begin with Descartes, whose philosophy, though Scholastic in many respects, marked a new departure in some ways.

Descartes (1596–1650), like others before him, was keenly dissatisfied with the state of knowledge in his time. The only study which appeared to him well-founded was mathematics. This, he thought, was due to the method employed in mathematics, which sets out from clear ideas (axioms, definitions, postulates) and proceeds deductively to indubitable results. So he wanted to introduce the mathematical method into philosophy. For this he needed first of all a sure starting point. To find this he resorted to St. Augustine's " methodical doubt," and, like him, found that though he might doubt everything else he could not doubt the reality of his own doubt. " I think, therefore I am." Now, why is this accepted as certain ? Because it is " clear and distinct." If so, he gets the general principle that " whatever I apprehend very clearly and distinctly is true." And among such clear and distinct, and therefore true, ideas he includes those of God, the axioms of geometry, and such " eternal truths " as that " nothing can result from nothing." Nevertheless Descartes found it desirable to *prove* the existence of God; and for this purpose he drew mainly on the arguments of St. Anselm and Campanella. Next, relying on the veracity of God, whose perfection would refrain Him from deception, Descartes accepts the reality of the world of experience in so far as this is very clear and distinct. This world is the creation of God, and is entirely dependent on Him also for its continuance. The created world consists of two main classes of things, namely, bodies (or " extended things ") and minds (or " thinking things "). Like St. Augustine, Descartes regarded bodies and minds (or souls) as so utterly different that there can be no interaction between them. The union of body and soul in man is just a miracle. With the miraculous aid of God the soul can *direct*, though not *produce*, the movements of the body. This supernaturalist strain in Descartes' philosophy soon developed into " Occasionalism," that is, the doctrine that body and soul exercise no influence whatever on each other, but that any change in either serves as an occasion for divine intervention to produce a corresponding change in the other. In his scientific work Descartes followed the mechanistic lead of Galileo. He even tried to explain animal organisms (including the human body) as mere automata or machines. His most original and valuable discovery was that of Analytic Geometry.

Hobbes (1588–1679) was strongly opposed to supernaturalism. He attempted to apply to the whole world of reality the kind of mechanistic explanations which Galileo and Descartes had applied to physical phenomena only. His naturalism thus assumed the extreme form of materialism. According to it matter and motion are the sole ultimate realities, and account for everything, even for human knowledge. For all knowledge is derived from sensations, and all sensations are produced by the pressure of matter on the sense organs. In fact sensations and even thoughts are only certain kinds of motion, and mind (or soul) is matter. All things, moreover, are characterized by the same fundamental tendency, namely, the tendency to persist in their present condition, whether of motion or of rest. Hobbes did not deny the existence of God as first cause, but he

maintained that man " cannot have any idea of him." Hobbes' main influence lay in the realm of moral and political philosophy, and even there it showed itself chiefly by provoking opposition.

Spinoza (1632–1677) was the first modern to give complete expression to the naturalism and rationalism with which modern thought reacted against the supernaturalism and dogmatism of the Middle Ages. He vindicated the autonomy of reason against every kind of authority, insisting that even the Scriptures must be submitted to the same kind of examination as any other historical documents. Now the characteristic function of reason is to discover the systematic connections between things. It is therefore opposed to any supernatural incursions which tend to break up the systematic interconnections between natural events. Hence we find in Spinoza rationalism and naturalism going hand in hand. But his naturalism is very different from the naturalism of Hobbes. In Nature, as he conceives it, there is room for the mental (or spiritual) as well as the material, and for the divine as well as the human and subhuman. In fact, for Spinoza Nature (or the cosmic system) and God are the same. The All is God, and God is All. Let us glance at the ground and structure of Spinoza's pantheism.

Every finite object or event is dependent on innumerable others, which ramify in all directions, and are each of them similarly dependent on innumerable others. But a world consisting solely of such contingent objects and events would be unintelligible. There must be some self-dependent reality (or " Substance ") which sustains all the dependent things and events. But this self-existing " Substance " need not be sought in an external creator ; the cosmic system (or Nature) in its entirety may satisfy this quest for God. Scientifically, this view avoids the unnecessary multiplication of entities, and the problem of creation from nothing. Nature or God is thus conceived as all-comprehensive, infinite or perfect, so that there is nothing outside the cosmic system, nothing supernatural. Nature, moreover, is not static but dynamic, exercising all existing forms of energy. Each ultimate kind of energy is described as an Attribute of God. Man only knows of two such ultimate attributes, namely, extension and thought, that is, physical energy and mind energy. But there may be an infinity of others. All material bodies and physical events are " modes " (that is, modifications or states) of the attribute extension, and all minds and mental experiences are modes of the attribute thought. The apparent interaction between body and mind arises from their being concomitant modes of the constitutive attributes of the one ultimate reality. The various finite modes are not illusions, but real while they last ; and even when they pass away they do not utterly disappear, for the One remains in which the many change and change again. Spinoza is so opposed to anthropomorphism and its abuses that he declines to describe God as a Person ; but only because He is so much *more* than we can understand by a person. God, as Spinoza conceived Him, is super-personal, but not less worthy of love for that, as is clear from Spinoza's life and character. In fact Spinoza's philosophy culminates in " the intellectual love of God," which is the fruit of that highest intuition to which man attains when, after an adequate discipline of intelligence and character, he arrives at a synoptic vision of the One and All.

Leibniz (1646–1716) formulated a philosophy of Monadism. He held that so-called material objects, and even space, have no objective reality, but are mere appearances within the experiences of minds. Minds (souls or spirits) are the only realities. They are of all degrees of development, some having but a very low kind of consciousness or sub-consciousness, a kind of chronic somnolence, others are in a somewhat higher dream-state, yet others are wide awake and have clear thoughts, while God ("the monad of monads") enjoys the most intense and most active consciousness. The monads are infinite in number and infinite in gradation, no two monads being exactly alike. Moreover, each monad is self-contained and is not affected by the others, except only by God who has created them by a kind of emanation. The appearance of interaction between different monads is due to a "pre-established harmony." God, in other words, has so made them that they all act in harmony. It is as if He had set a number of clocks to keep time together. The whole outlook bears the impress of supernaturalism. Yet in dealing with so-called physical phenomena Leibniz sought mechanical explanations, though he tried to reinstate also teleological explanations by treating mechanism as an instrument of teleology. The ultimate motive which prompted this idealistic monadology was the anxiety to justify the belief in the ultimate reality and permanence of individual souls.

Locke (1632–1704) attempted to divert philosophy from ambitious cosmic speculations to the study of the nature and limits of human knowledge. He was wont to discuss religious problems with certain friends of his, but the discussions seemed fruitless. It then occurred to him "that before we set ourselves upon inquiries of that nature, it was necessary to examine our own abilities, and see what objects our understandings were or were not fitted to deal with." For by "extending their inquiries beyond their capacities" people "raise questions and multiply disputes, which . . . only . . . increase their doubts." The main results of his examination of the human understanding may be briefly summarized as follows. Our understanding is dependent on sensations. It can reflect on these, and combine them into more complex wholes, but it cannot add to them. Now sensations are at best only appearances or copies of the primary qualities of things (extension, shape, solidity, number, motion). Sensations of secondary qualities (colour, smell, sound, taste) are merely subjective effects produced in us by primary qualities, and are not copies of anything objective. Our ideas of substances (bodies and souls) are vague, and cannot be justified by sense-experience. Hence it is impossible to say whether the soul is a spiritual substance, or a material substance endowed with the capacity to think. In fact, man does not know the "real essence" of anything, and is strictly limited to his experience. Each man can only be sure of his own existence, by intuition, and of the existence of God as the cause of man's existence. So, three years after the publication of Newton's *Principia*, Locke's *Essay* (1690) considered "a science of physical bodies as out of our reach" (beyond merely empirical limits), while regarding mathematics and ethics as real sciences because they are only concerned with ideas.

The five seventeenth-century systems of philosophy outlined above may be said to have provided the broad foundations for all, or nearly all,

the philosophies which appeared during the two centuries and more that have elapsed since then.

Eighteenth Century Philosophy

Berkeley (1685–1753) formulated an idealistic philosophy to counter the materialistic tendencies of his age. The progress of mechanics in the seventeenth century had been so striking that thinkers naturally attempted to extend mechanistic modes of explanation (that is, explanations in terms of matter and motion) in all directions. The materialistic philosophy of Hobbes was a supreme example of this tendency; and Hobbes did not stand alone. Good Bishop Berkeley tried to refute the whole movement by disproving the reality of matter, in favour of spirits and ideas. Taking Locke's *Essay* for his text, Berkeley maintained that our ideas or sensations of primary qualities, as well as those of secondary qualities, cannot be " copies " of anything objective, but are mental experiences, and nothing else. Ideas can only resemble ideas, not material objects or their qualities. It is therefore unwarranted and superfluous to assume the existence of material bodies at all. Our ideas themselves, and not the alleged material things beyond them, are the real objects of knowledge. " All the choir of heaven and furniture of earth . . . have not any substance without the mind; . . . their *being* is to be perceived or known." When they are not perceived by man, then " they must either have no existence at all, or else subsist in the mind of some Eternal Spirit." But how is it that material bodies appear to produce certain effects with such regularity, if they are only ideas? Berkeley explains this as the result of " an arbitrary connection instituted by the Author of Nature " between the corresponding ideas. The only realities, then, are God, other spirits or souls created by Him, and the various ideas or experiences which He has ordained to be apprehended in certain regular sequences.

Hume (1711–1776) maintained that the line of argument pursued by Locke and Berkeley ends in scepticism. Berkeley had argued that, on Locke's own showing, there is not enough evidence for assuming the reality of material substances or material causation, though he insisted on the reality of spirits (or souls) and spiritual agency. Hume maintained that Berkeley's arguments against the former were just as valid against the latter. He repudiated Berkeley's contention that each man has an intuition of his own soul or self. " For my part when I enter most intimately into what I call *myself*, I always stumble on some particular perception or other. . . . I never catch *myself*." All that seems to be real is a miscellaneous multitude of disconnected impressions and ideas, to which habitual association gives the appearance of causally connected events, while our mistaking of similar impressions for identical ones gives them the appearance of enduring substances. The flux of changing experiences is all that is sure. Even mathematics is not certain. The most that can be claimed for anything is probability. Hume himself found his conclusions baffling, but he pleaded " the privilege of the sceptic."

Kant (1724–1804) attempted to bridge the chasm between ideas and the external world in which Hume's philosophy ended. This divorce

between the subjective and the objective was the natural result of the line of thought pursued by Descartes, Leibniz, Locke, and Berkeley. But Kant had too much respect for the achievements of science to dismiss their claims in the manner proposed by the scepticism of Hume. And his defence of the sciences took the form of a comparatively new method, the so-called "transcendental," which was a striking development of the older doctrines of "common notions," "eternal truths," and "innate ideas." Kant conceived the objects of knowledge as the joint production of sense-materials, which are independent of the mind, and of certain forms and relations which the mind contributes. These forms of intuition (space and time) and relations or categories of thought (substance and attribute, cause and effect, etc.) are *a priori* or "transcendental" in the sense that they are not learned from experience, since experience itself would be impossible without them. On the other hand, the sense-material is *a posteriori*, that is, only given in experience, though it is given not as it is "in itself" but only as transformed by the *a priori* forms and categories. Human knowledge does not extend to "things-in-themselves" (or noumena) but only to their appearances (phenomena) as moulded in the way just indicated. The application of the *a priori* forms and categories to whatever falls within human experience is legitimate and, in fact, inevitable. But they must not be applied to whatever transcends such experience. God and future life, for instance, are beyond human experience, and consequently cannot be argued about at all—they can be neither proved nor disproved. But they may be *believed in* as a matter of *faith* based, not on theoretical, but *on practical grounds*. And it is on such practical considerations that Kant based the belief in the existence of God, freewill, and immortality. These are postulated by the unconditional claims of morality (the "categorical imperative"), just as the reality of an objective world of some sort is postulated by the theoretical claims of science.

Materialism

In opposition to the idealism of Berkeley his countryman Toland (1670–1721) advocated the materialism of Hobbes. He insisted that matter was not the inert thing that Descartes had represented it to be, but an *active* substance or *force*. Matter is force, motion, life, and mind is one of its functions. Thought is a function of the brain, just as taste is a function of the tongue. *Hartley* (1704–1757) likewise embraced a materialistic philosophy, and attempted to reduce psychology to physiology. Priestley (1733–1804) was perhaps the most important British materialist of the eighteenth century. He enumerated many plausible reasons in support of materialism (some of them actually drawn from the Bible), and argued that only on the assumption of God's materiality can the Christian dogma of His omnipresence be maintained. In France materialism was stimulated unintentionally by Descartes. Descartes was a dualist and theist, in fact an orthodox Catholic, but his view that the lower animals are mere automata, and his account of how all the limbs can be set in motion by sense stimuli without the intervention of the soul, led La Mettrie and others to dispense with souls altogether, and to explain

all things mechanically. La Mettrie (1709–1751) insisted that man is not a privileged being, and that there are no ultimate differences between plants, animals, and men. They are all subject to the same laws, and represent different stages of one evolutionary process. Other French materialists were Diderot (1731–1784), Helvetius (1715–1771), D'Alembert (1717–1783), D'Holbach (1723–1789) and Cabanis (1757–1808). To Cabanis are due some of the most familiar dicta of materialism. Body and soul are the same thing. Man is just a bundle of nerves. The brain secretes thought just as the liver secretes bile. All things, even the so-called mental and moral phenomena, follow from the laws and properties of matter. Phrenology was naturally an offspring of this kind of materialism.

Eighteenth Century Science

The progress of astronomy after Newton proceeded along two main lines, observational and mathematical. The most important work in observational astronomy in the eighteenth century is associated with the name of Herschel (1738–1822). In 1781 he discovered a new planet (Uranus) with two satellites beyond Saturn. Even more significant in some way was his discovery of 800 double stars, that is, pairs of stars revolving about each other according to the law of gravitation. This showed that the law held beyond the solar system. He also catalogued 2,000 nebulæ, which he conceived to represent different stages in the development of planetary systems. Moreover, by comparing the distribution of stars in the heavens he concluded that our star-system is approximately lens-shaped. Mention must also be made of Halley's observation of comets and his determination of the periodicity of two of them. Equally important was his discovery that certain fixed stars were changing their relative positions, and so were not really "fixed." Mathematical astronomy was mainly concerned with the development of the implications of the laws of gravitation and motion. The chief problem was how to determine the relative motions of three or more mutually attracting bodies. Euler, D'Alembert, Clairaut, and Lagrange worked out this problem with special reference to lunar and planetary theory, and the results of their labours were systematized and rounded off by Laplace in his *Celestial Mechanics* (1799). Laplace showed that the solar system is stable, the mutual interferences of its parts never exceeding certain limits. Laplace also made the first scientific attempt to explain the origin of the solar system. According to his Nebular Hypothesis (1796) the planets have condensed from rings thrown off by a rotating and contracting mass of glowing gas. This hypothesis had to be abandoned a century later, but is still accepted as a true account of the condensation of single stars out of a nebula.

In physics the eighteenth century made important contributions to the study of heat, sound, magnetism and electricity. Black's experimental work in heat led him to the discovery of specific heat and of latent heat, the latter of which was an important factor in Watt's discoveries in steam engineering. Rumford's experiments succeeded in establishing the hypothesis that heat is a mode of motion, not a kind of stuff like phlogiston

with its ambiguous "levity." In the study of sound Hawksbee, in 1705, first proved experimentally the dependence of sound on air, while Chladni (1756–1827) brought the study nearly to its present level. In the study of magnetism and electricity eighteenth century scientists made amends for the comparative neglect into which it had fallen since the days of Gilbert. A beginning was made by Hawksbee and the work was carried on by numerous investigators including Franklin, who established the electrical character of lightning, and Galvani and Volta, whose names have become household words through the "galvanic" battery, "galvanism," the "voltaic pile" and "voltage," etc.

In chemistry the eighteenth century is chiefly noteworthy for the first systematisation of the science, for a number of positive discoveries, and the disproof of several long-established errors. The century commenced rather unpromisingly with the phlogiston theory of Stahl (1660–1734). This was a glorified form of the old belief that in combustion a special kind of fire-matter (phlogiston) was given off. Thus, *e.g.*, when a metal was changed into a calx by heating, this was taken to show that the original metal consisted of the calx and the phlogiston, and that the latter was given off during the combustion. This hypothesis helped to bring some order into the chaos of many chemical details, but came into conflict with others. For instance, it had been observed already by an Arab chemist of the eleventh century that when a metal is calcined in the air it gains in weight. The supporters of the phlogiston theory met the case by saying that the phlogiston has levity instead of gravity, buoyancy instead of weight, and so its combination with the calx of a metal makes the metal lighter than is the calx by itself. Several discoveries, however, soon helped to disprove this old fancy (originally based on the obvious upward tendency of flame), though the discoverers did not always see the significance of them in this connection. Black (1728–1799) showed that when chalk is changed into quicklime it gives off a gas different from air. This led to the search for other gases. Priestley (1733–1804) and Scheele (1742–1786) discovered independently the gas subsequently called oxygen. The gas was obtained by heating calx of mercury. This discovery led Lavoisier (1743–1794) to the correct interpretation of calcination. He showed that in combustion the combustible matter combines with oxygen, which is one of the gases constituting air. Thus the calx of, say, a metal contains more than the metal did, and that is why it is heavier. The phlogiston theory was therefore disproved. Incidentally, it was also shown that air is not an element. Water too was shown to be a compound when Cavendish (1731–1810) discovered hydrogen and, by synthesizing it with oxygen, produced water. The principal honours of eighteenth-century chemistry go to Lavoisier, who extended and systematized all the good chemical work done up to his time. He gave vogue to Boyle's stricter use of the term "element," introduced a more scientific system of chemical names, set an example of the use of chemical equations, and virtually formulated the principle of conservation of matter when he postulated that "in every operation there exists an equal quantity of matter before and after the operation." The execution of Lavoisier by the leaders of the French Revolution was an irreparable loss to chemistry, and a warning that fanaticism is not the monopoly of religion.

The biology of the eighteenth century was mainly preparatory for the century of evolution. But a great deal was attempted and something was accomplished in descriptive biology, systematic biology, and in more speculative biology. In his *Natural History* Buffon (1707–1788) gave the most elaborate account known up to his time of the life, habits, geographical distribution of animals, and of the climatic and other conditions in which they lived. This work did much to make the study of natural history popular. Scientifically Linnæus (1707–1778) was more important than Buffon, for he did much to systematize biology, by introducing an improved classification of plants and an improved system of names, which are still useful for purposes of identification. The Linnæan system of classification is known as the Sex System. It was still rather artificial, but, in conjunction with the work of Jussieu and others, it prepared the ground for a natural classification based on kinship. The ancient belief in spontaneous generation of animals was still very common, but the experiments of Spallanzani (1729–1799) helped to discredit it, and moreover set an example of accurate experimentation in connection with this kind of problem. Of special importance to the future of biology was the introduction of the comparative method, which led gradually to the accumulation of the kind of evidence on which the theory of evolution was eventually based. In this connection Buffon's *Natural History* and Goethe's *Metamorphosis of Plants* may be specially credited with the popularization of the general idea of evolution. Intimately connected with the evolutionary ideas in biology was the new interest that was directed to the study of fossils, and of geology in general. In his *Theory of the Earth* (1788), Hutton (1726–1797) laid the foundations of scientific geology. In the sphere of applied biology the event of outstanding importance was the discovery of vaccination by Jenner (1749–1823), who thereby laid the foundations of preventive medicine.

Nineteenth Century Philosophy

Idealism. Although Kant himself had uttered a warning against speculation about the thing-in-itself, or Absolute, yet his writings contained suggestions which stimulated a number of thinkers to devote themselves just to that " forbidden fruit." The best known of these thinkers were Fichte, Schelling, and Hegel.

Fichte (1765–1814) maintained that even the thing-in-itself is the product of the mind. The whole of experience, not its form only, is generated by the " absolute self," in which individual minds participate. The " absolute self " divides itself into a knowing self and a known object, because the moral growth of the self needs objects as obstacles to be surmounted by moral endeavour. For similar reasons the absolute self must divide into many selves, otherwise there would be no opportunity for the exercise of mutual duties. But the many selves are all expressions of one moral order, which is the absolute self or God.

Schelling (1775–1854) attempted to rescue the reality of the physical world from the idealist tendency to explain it away as mere appearances or ideas. He regarded the beauty of the material world as a sufficient justification of its reality, and he conceived it to be an expression of the

Absolute just as mind is. This led to the view that the Absolute is neither mind nor matter though it expresses itself in both. Thus the Absolute reverted to the position of an unknown thing-in-itself.

Hegel (1770–1831) rejected the idea of an unknown thing-in-itself or Absolute. Mind and physical Nature, he insisted, *are* the Absolute, not merely appearances or expressions of an otherwise unknown Absolute. Moreover, mind and matter are not two distinct realities but integral components of one process of self-revelation of the Absolute. Mind needs an objective world on which to exercise itself; but this objective world is itself mental. "The real is rational, and the rational is real." Moreover, the development of reality proceeds like a dialectic. Some thought occurs (thesis). It is opposed by another thought (antithesis), which also proves to be inadequate. But a third harmonizes what is true in the first two (synthesis). Thus, for instance, "becoming" is such a synthesis of "being" and "non-being." The whole world is composed of such syntheses. And Hegel's conception of the world-process as a rational dialectic gave a new impetus to the study of history, which came to be regarded as the unfolding of a divine drama. Unfortunately Hegel's philosophy lent itself to opposite applications. Young revolutionaries took for their motto one half of Hegel's dictum, namely, "the rational is real" or is bound to become real; conservatives and reactionaries adopted the other half of the dictum, namely, "the real is rational," what is, is right.

Fechner (1801–1887) regarded the universe as a society of souls, and God as the supreme all-embracing Soul. Inwardly all souls are mental, but outwardly they appear to each other as material bodies. And just as smaller bodies are included in larger bodies, and all bodies are included in physical nature, so some souls are included in others, and the soul of God embraces all other souls. Life and consciousness do not evolve out of the lifeless and the unconscious, rather these are degradations of the former by a kind of secondary automatism.

Lotze (1817–1881) propounded an idealistic pantheism. Ultimate reality is mental Substance. Material phenomena are appearances produced by souls or spiritual monads (as Leibniz had maintained), but those monads Lotze (in opposition to Leibniz) regarded, not as independent substances, but as modes or states of God, who is the sole and infinite Substance. Mechanistic phenomena are appearances resulting from the uniform laws with which God carries out these immanent activities, which are nevertheless directed to divine ends.

Voluntarism. Whereas the Idealists identified ultimate reality with thought or reason, other philosophers identified it with will. Already Descartes had given primacy to the will, and Kant had given some encouragement to this tendency by treating the highest truths as moral or practical postulates. The chief voluntarists were Schopenhauer, Hartmann, Nietzsche, and Wundt.

Schopenhauer (1788–1860) identified ultimate reality with an irrational "will-in-general," or universal will. There are no individual things or wills. Individuality is mere illusion. For it depends on differences of time and place, which Kant had shown to be merely forms in which the

things-in-itself appears, not constituents of it. Moreover, the will is essentially evil, and can never be satisfied. Life is a welter of unsatisfied cravings. The best course is to see through the illusoriness of individuality and the futility of the quest for satisfaction, and look upon life as if it were a work of art. Thus Schopenhauer's pessimism ended in a kind of Buddhist self-renunciation.

Hartmann (1842–1906) developed the voluntarism and pessimism of Schopenhauer into a "philosophy of the Unconscious." Whereas Schopenhauer treated representation (or cognition) as a mere instrument of will, Hartmann puts them both on the same level. Together they constitute the "unconscious" Absolute, which gradually differentiates into the two, becomes conscious, and realizes the tragedy of the will to live. By setting the two (will and representation) against each other (for instance, by devotion to such intellectual pursuits as those of the sciences), they may both be annihilated, and the evils of existence may be brought to an end. In this way mankind may redeem its "unconscious" God.

Nietzsche (1844–1900) attempted a synthesis of Kant, Schopenhauer, and Darwin. The inference he drew from Kant's theory of knowledge was that there is no such thing as knowledge, only fiction. Truth is not discovered, but created or invented. Beliefs, indeed, are not all alike. But the proper distinction is between those which are *useful* and those which are *useless*, not between those which are *true* and those which are *false*. Like Schopenhauer, Nietzsche identified ultimate reality with will, but he characterized this will as a "will to power," not merely as a "will to live." "The love of power is the dæmon of mankind." Like Schopenhauer, Nietzsche saw the world in sombre hues, but, instead of preaching an ideal of Buddhist acquiescence, he urged the gospel of energetic and dangerous living. Life is a kind of Greek drama in which the hero shows his mettle. The "struggle for existence" has the merit of bringing the superior men to the top. And Nietzsche looked forward to the coming of "supermen" as the result of the "survival of the fittest." The "superman" will surpass the existing human type as much as present-day man surpasses the ape.

Wundt (1832–1921) also identified basic reality with will, but a will which is never entirely divorced from feeling and ideas. There are two grades of will, namely, impulsive and voluntary (or deliberate) will. Even impulsive will needs feeling directed toward an end, and therefore an idea, but not that conscious adoption of a motive which characterizes voluntary will. As all organisms have impulsive will, organic evolution is teleological, mechanism being invented by it as an instrument for its own ends. Wundt identified will with activity of every kind. Hence, not only attention but even thinking is identified with will. This led to William James's doctrine of the "will to believe." Like Kant, Wundt restricted human knowledge to experience. In so far as reason attempts to transcend experience, it can only posit "ideals of faith." God is such an ideal conceived as the world-will.

Materialism. The middle of the nineteenth century witnessed a revival of materialism, especially in scientific circles. This was largely a kind

of reaction against idealism and its rash incursions into the domain of science. The generation which witnessed the physical experiments of Mayer, Joule, and Helmholtz (who established the principle of conservation of energy), the chemical researches of Liebig, and the microscopic investigations of Schwann (who showed the cell to be the unit of animal as well as of plant organisms) and of Schleiden (who rejected vitalism) had no patience with the romantic fancies of idealists, and their rejection of the reality of matter. Moreover, advances made in the technical arts, and the resulting improvements in industrial and economic conditions, helped to encourage a special interest in things material. So contact was renewed with the materialism of the preceding centuries. Moleschott (1822–1893) described the whole cycle of life in terms of matter and energy. "No sulphur, no thought." Vogt (1817–1895) added to this dictum the one of Cabanis, that the brain secretes thought as the liver secretes bile. Büchner (1824–1899) was probably the most important of this group of thinkers. His book *Force and Matter* served for a long time as the armoury of materialism. He identified all force with motion, and regarded everything as produced by matter and motion. But, though he distinguished between matter and motion, he insisted that they are inseparable. Rejecting vitalism, he regarded life as generated spontaneously out of matter under certain conditions, and that mental process is only "a radiation through the cells of the grey substance of the brain of a motion set up by external stimuli." Czolbe (1819–1873) condemned everything super-sensible as "transcendental nonsense." But he did not think that Büchner's "force and matter" would explain everything. It was necessary to assume organic forces, mental elements, etc., as well as material atoms and motion. And he regarded the natural system as an harmonious and purposive whole. It is worth noting that all these materialist scientists and philosophers were filled with enthusiasm for humanity and human progress.

Positivism and Evolutionism. The whole trend of modern science was away from supernaturalism, and even those who were not satisfied with the philosophy of materialism had recourse to a philosophy which refrained from supernaturalism, and conceived the world as a naturalistic system of law and order. This usually entailed moderation in metaphysical speculation or a certain amount of agnosticism. Comte, Mill and Spencer are the chief representatives of this movement, which was influenced partly by the empiricism of Locke and partly by the critical philosophy of Kant.

Comte (1798–1857) was the founder of what is known as Positivism. Like Kant he maintained that human knowledge is limited to phenomena, things-in-themselves being beyond our ken. It is therefore best for men to concentrate their efforts on the advancement of scientific knowledge and the amelioration of social conditions. Philosophers should relinquish the quest of what is unknowable (the Absolute, etc.), and take up the task of co-ordinating and systematizing the methods and results of the sciences. And religious devotion should be diverted from the fruitless service of an unknown God to the service of Humanity. In this way religion, instead of being a source of sectarianism and mutual

discord, will become a means of human solidarity. Such Catholicism without supernaturalism could only make very slow progress, as most people hanker after the supernatural. Mill (1806–1873) was also a positivist, though he was influenced by Locke rather than by Kant. His logic, his utilitarian ethics and his political economy were all worked out on positivist or empirical lines.

Spencer (1820–1903) likewise confined human knowledge to phenomena, but admitted an " unknown " ground of the phenomenal world. His fame rests mainly on his ambitious attempt to bring all things into one evolutionary scheme. The world, according to Spencer, began as an homogeneous something which may be called force or matter and motion, but whose inner nature is unknown. By its gradual differentiation there evolved first the heavenly bodies (more or less according to the nebular hypothesis of Laplace). The organic world then evolved out of the inorganic (on the lines of Lamarckian and Darwinian biology). Differentiation of structure and function in living bodies followed in due course, also division of labour in industry, and so forth. The total amount of energy in the universe remains always the same, it is only distributed variously. The evolutionary process was conceived by Spencer and others on mechanistic lines. Bergson's " creative evolution " and Lloyd Morgan's " emergent evolution " were intended to correct this mechanistic tendency, and to vindicate the spontaneity and originality of cosmic processes.

Nineteenth Century Science

Astronomy continued its advance along the lines followed in the preceding century, but with the assistance of new and powerful auxiliaries in photography and spectroscopy. Refinements in lunar and planetary theory led to the discovery of the planet Neptune in 1846. The existence and the position of the new planet had been inferred independently by Adams and Leverrier from a mathematical analysis of the irregularities observed in the movement of Uranus, and so afforded a striking confirmation of the principles of Newtonian astronomy. In observational astronomy Bessel's detection of stellar parallax, in 1838, was an event of great significance. The failure to observe parallax (that is, a change in the apparent position of fixed stars corresponding to changes in the position of the earth in its orbit) had been one of the chief objections to the heliocentric theory of Aristarchus and Copernicus. In the eighteenth century Bradley sought parallax, but only observed the aberration of light (which results from the observer's motion athwart the paths along which stellar rays reach him). Bessel's observation of parallax was a direct confirmation of the heliocentric theory. The nineteenth century also witnessed a much more accurate determination of the sun's distance from the earth than had been possible before. But the most remarkable novelty was the spectroscopic discovery of the chemical composition of the celestial bodies. The method used was briefly as follows. Each chemical element, when incandescent, emits a light which resolves by dispersion into a characteristic spectrum; and whenever this spectrum is detected in the light from a star, the presence of this element may be

reasonably inferred. Moreover, the displacement of the spectral lines of a star proves that the star is in motion relatively to the observer. In this kind of way the combination of photography with spectroscopy has yielded much information about the velocities, temperatures, and evolutionary stages of stars; and in some cases even their distances and masses can be inferred.

In the realm of pure mathematics the discovery of most general interest was that of non-Euclidean geometry. The principal workers in this field were Gauss, Bolyai, Lobatchevsky, and Riemann. It was shown that Euclid's axioms of geometry were not the only possible ones, that sets of axioms can be formulated arbitrarily, and self-consistent geometries based on them; also that the space assumed in Euclidean geometry is only a special case of a more general type. Non-Euclidean geometries first assumed physical significance when it was found that the space-time continuum required by Einstein's theory of gravitation is non-Euclidean.

In physics Rumford's ideas about heat were developed by Joule, who established the equivalence between the heat produced and the work or chemical energy expended in producing it. Helmholtz extended the principle of the mutual convertibility and conservation of heat and energy to the whole realm of nature, and in this form it became known as the First Law of Thermodynamics. Meanwhile Carnot had discovered that the working of a heat-engine involves the transfer of heat from a hot source to a colder sink. The ideas of Carnot had very important results. In the first place they led Lord Kelvin to the fruitful conception of an absolute scale of temperature. In the second place, in conjunction with Joule's discovery, they led Clausius and Lord Kelvin to the formulation of the Second Law of Thermodynamics, namely, that heat cannot of itself pass from a colder to a hotter body. As every transfer of heat from a hotter to a colder body tends to equalize the temperature of the universe, it was inferred that the universe is tending to a state of uniform temperature, in which no heat will be available for work. Since this tendency is irreversible, it has been described by Eddington as the only physical criterion for distinguishing the future from the past.

In the study of light, the nineteenth century opened with experiments by Young and Fresnel which favoured the undulatory theory formulated by Huygens. Fresnel, however, found it necessary to assume that light-waves are transverse, not longitudinal. This, in turn, involved the attribution of incompatible properties to the æther. But the work of Oersted, Ampère, Neumann, and Faraday in connection with electromagnetism was preparing the way for Maxwell's electromagnetic theory of light. The experimental results obtained by these physicists convinced Maxwell that electromagnetic charges do not act across empty space, but through a medium; and he succeeded in formulating equations expressing the fundamental electromagnetic laws in terms of the electrical and magnetic properties of any given medium. For insulating media (including most transparent media) these equations had a form characteristic of transverse wave-motion. Such electromagnetic waves were unknown then, but the equations showed that if they existed they would have a velocity nearly equal to that of light, would be transverse, and subject to reflection, refraction, and double refraction—just like light.

Maxwell accordingly suggested that light-waves may be electromagnetic waves of comparatively short wave-length. In course of time Hertz showed experimentally that such electromagnetic waves exist, and that they behave like light-waves. The unification of the two kinds of waves and of their two media was a great simplification, and prepared the way for a still greater simplification, namely, Einstein's provisional unification of the phenomena of the electromagnetic and the gravitational fields as manifestations of the same structure of space. The upholders of the older mechanistic ideas are not quite reconciled to these newer views. The unitary electric charges which have to be assumed in connection with Maxwell's electromagnetic fields are regarded by them as corpuscles rather than as wave-groups, and as favouring a quasi-Newtonian hypothesis of light as consisting of corpuscles having associated wave-trains.

The discoveries of Galvani and Volta in current electricity were fully developed in the nineteenth century. The magnetic property of the current was discovered by Oersted in 1820, and its mathematical laws were investigated by Ampère, Faraday, Neumann, and Maxwell. Radiotelegraphy and the dynamo were the practical fruits of these researches. The chief quantitative laws of the electric circuit were determined by Ohm, Joule, and Weber. What is specially interesting, however, is the important rôle which electromagnetic theory played, and is still playing, outside its special domain. This has already been noted in connection with the theories of light described above. Something similar will be observed in connection with chemistry. For it was soon discovered that electric current has chemical properties which help to analyse chemical compounds into their elements. In this way Davy discovered a number of new metals. Faraday ascertained the quantitative laws governing electrolytic decomposition. He also suggested a theory of electrolysis, which was developed by Clausius and Arrhenius, to the effect that a certain percentage of the molecules of the dissolved salt are dissociated, by the mere process of solution, into oppositely charged particles which the subsequent application of an electric field impels in opposite directions. At the electrodes they lose their charges and so maintain the flow of current.

Chemistry at the beginning of the nineteenth century was mainly concerned with the exploitation of the atomic theory in the service of the special problems of chemical science. A first attempt in this direction had already been made in 1789 by W. Higgins, but it made no impression. A real advance was first made by Dalton (1766–1844) early in the nineteenth century. He held that each kind of elementary substance consists of a special kind of atoms, that each kind of atom has a characteristic weight, and that chemical combination takes place always between simple numbers of atoms. Assuming that in a combination of two elements there is one atom of each for every atom of the other, the relative combining proportions by weight should give the relative weights of the two kinds of atoms. Next, taking the atomic weight of hydrogen as the unit, he drew up a table of the atomic weights of the elements known in his day. His assumption was unwarranted, but his main theory served as a basis for the first quantitative laws formulated about that time—the laws of definite, multiple, and reciprocal proportions. In 1809 Gay-Lussac

showed that gases reacted with each other in simple proportion by volume, and in 1811 Avogadro distinguished between molecules (that is, clusters of atoms) and (single) atoms, and postulated the existence of molecules in elementary gases. On combination one molecule might break up into two or more atoms. From all this it was deduced that the density of a gas is proportional to the weight of its molecules. Here was a means of surmounting some of Dalton's difficulties. But this line of research was not pursued further until Cannizzaro took it up again in 1858. In the interval Berzelius was busy determining atomic weights. But atomic weights were neglected in favour of the "equivalents" introduced by Wollaston in 1814, especially when Faraday discovered the Law of Electro-Chemical Equivalents in 1834. The use of a variety of chemical units caused much confusion until Cannizzaro helped to introduce some uniformity.

One of the most notable triumphs in nineteenth-century chemistry was achieved in 1828, when Wohler prepared for the first time an organic substance from inorganic materials. This, coupled with Berzelius' discovery, in 1814, that organic substances obey the ordinary laws of chemical combination, helped to banish the mystifying "vital force" which had been assumed to produce organic substances from carbon, hydrogen, oxygen, nitrogen, and phosphorus. Another notable achievement of nineteenth-century chemistry was Mendeléeff's discovery of the Periodic Table of Elements. Developing the suggestions of other chemists (notably L. Meyer and Newlands) Mendeléeff showed that the elements, when arranged in the order of their atomic weights, fall into series showing a periodicity of properties. By means of this periodic table he predicted the atomic weights and physical properties of various unknown elements which were subsequently discovered. Subsequent research by Moseley showed that the periodic table could be much improved by substituting an arrangement according to atomic numbers instead of atomic weights. Yet another noteworthy feature of the period is the tendency, started by Prout, to regard atoms of hydrogen as the ultimate constituents of all other kinds of atoms. This tendency to seek a common origin for all the different kinds of atoms, coupled with other influences, culminated subsequently in the conception that all kinds of atoms are composed of protons and electrons. For all practical purposes, of course, the differences between the elements retain their significance. And one simple way of indicating the progress of chemistry during the nineteenth century is to point out that whereas only some thirty elements were known at the beginning of the century, nearly eighty were known at the end of it.

Great as the scientific advances of the nineteenth century were in other directions, its most characteristic advance was in the realm of biology. It was essentially the age of evolution.

But before turning to the subject of evolution, a brief account must be given of certain other aspects of nineteenth-century biology, with special reference to the work of Pasteur on microbes or bacteria. The existence of minute rod-like organisms was first discovered by Leeuwenhoek about 1683. But the subject received little attention until the nineteenth century, when Schwann proved experimentally that putrefaction and

alcoholic fermentation are the work of minute living organisms. In 1857 Pasteur took up the problem. He devoted himself to the closer study of these microscopic organisms, and founded the science of bacteriology. He showed that lactic, ammoniacal and other forms of fermentation also depend on bacteria. In 1873 he turned his attention to the study of contagion, thinking that it may be due to infection by specific germs. He showed in course of time that the silk-worm disease, anthrax or splenic fever in sheep and other animals, and chicken cholera are each the effect of the activity of a specific kind of germ. Later on the specific microbes of yet other diseases were discovered. One practical result of Pasteur's discoveries was the introduction by Lister of antiseptic surgery in 1887. This, coupled with the previous discovery of anæsthetics by Davy and others, made surgical operations much safer than they used to be. Moreover, following the example of Jenner's method of vaccination, Pasteur prepared various attenuated toxins, inoculation with which served to prevent, or to cure, such diseases as anthrax and hydrophobia, or rabies. Pasteur's work thus greatly advanced medical and surgical art as well as biological science. It also had important consequences in the field of practical agriculture. These biological discoveries were of the utmost practical importance, yet they were overshadowed by a mere theory—the Theory of Evolution. To this we must now turn.

In a vague kind of way the idea of evolution was an old idea, and familiar to many people by the end of the eighteenth century. But the nineteenth century witnessed the steady accumulation of vast masses of scientific evidence, which converted the idea of evolution from a mere speculation into a well-defined and well-supported scientific theory. Much of the evidence was actually prepared by scientists who did not accept the idea of evolution; but this only gave additional value to their contributions. The main facts may be briefly outlined as follows. Cuvier laid the foundations of the science of palæontology by his studies of extinct vertebrates. Beginning with the examination of all known kinds of elephants, recent and fossil, he passed on to the study of all the extinct kinds of vertebrates accessible to him, and in 1821 published a very full and well-illustrated account of nearly a hundred of them. These descriptions suggested to some people theories of descent, say, of the modern horse from the extinct palæothere. But Cuvier cautiously asked for evidence of the existence of intermediate stages, and they were not known then, though they were discovered subsequently. In any case Cuvier's work made it possible to trace, however imperfectly, the descent of some modern ungulates (hoofed animals). Side by side with palæontology there arose the science of comparative embryology, which was founded by Baer. Starting from Pander's full account of the early stages in the development of a chick, Baer carried the work much further, and eventually formulated the principle that the development of an animal is a process of differentiation from the homogeneous to the heterogeneous. He compared it with Laplace's account of the development of the solar system from the nebula. In 1828 Baer appears to have inclined to the belief that the embryological evidence seemed to point to a common origin of the main types of animal life. About a year or two after Baer's

death Schleiden and Schwann published their cell theory, that is, that all plants and animals are composed of cells. It was shown that the individual cells of a complex organism are generally alive, and sometimes remain alive after separation from the main body. In 1843 Barry showed that certain protozoa are single cells, which are capable not only of motion but also of self-support. In due course all multicellular organisms, their tissues, the fission of these tissues, etc., were all traced to the protozoa. The cell theory thus exercised a great unifying influence, even linking up to some extent plants with animals. Lyell's *Principles of Geology* (1830) refuted the view that sudden catastrophes had repeatedly interrupted the succession of living things on the face of the earth. In 1845 Darwin made evolutionary suggestions in the new edition of his *Journal*. And a few years later Hofmeister gave a well-authenticated example of evolutionary descent in his accounts of flowering plants and higher cryptogams (plants which are flowerless or in which fructification is concealed). In 1859 Darwin published his *Origin of Species*, setting out the main lines of evidence on which he based his theory of the evolution of species by natural selection. It had taken him twenty years or more to collect the data and to make the experiments in support of the theory which first gave to the biological sciences a principle of synthesis comparable, to some extent, with Newton's law of gravitation in the realm of the physical sciences.

Some of the chief ways in which Darwin's theory helped to unify and explain various biological phenomena may be indicated briefly as follows. (1) *Affinity*. From the sixteenth century onwards biologists felt that there were affinities between certain plants, and attempted to classify them according to their affinities, but could give no intelligible account of the nature of affinity. Darwin showed " that community of descent is the hidden bond which naturalists have been unconsciously seeking," " that the characters which naturalists consider as showing true affinity between any two or more species, are those which have been inherited from a common parent, all true classification being genealogical," the natural system of classes being founded on " descent with modification." The influence of Darwinism on botanical and zoological classifications has, of course, been enormous. (2) *Survivals*. The presence in embryo birds and mammals of such things as a series of paired clefts along the side of the neck, along which are arranged vessels as in gill-breathing vertebrates, can only be explained on the assumption that the ancestors of birds and mammals breathed by gills. Similarly with other survivals. (3) *Homologous structure*. Such limbs as the pectoral fin of the fish, the paddle of the whale, the wings of birds and bats, and the hand and arm of man perform such diverse actions as swimming, flying, grasping, yet they all show a common plan. And this is only intelligible on the assumption that the common plan of the fore-limbs of the different vertebrates has been inherited from a common ancestor. (4) *Fossil remains*. The vast collections of fossil remains gathered by palæontologists can be interpreted only in the light of Darwinism. In some cases, notably that of the horse, the series of stages in their evolution has been so fully worked out that even Cuvier would most probably have changed his views on the immutability of species. (5) *Naturalism*. By a careful selection of suitable cases, various

naturalists had tried to base a natural theology on the evidence of adaptation in nature. The existence of predatory animals and noxious insects, etc., was either ignored or attributed to the devil. The doctrine of natural selection and the survival of the fittest helped to put an end to such supernaturalist speculations in biology, and thus brought the biological sciences within the naturalistic scheme of the physical sciences.

Largely through the influences of evolutionary biology, the same kind of naturalistic attitude has been introduced into such human and social sciences as psychology, anthropology, sociology, and economics. Religion itself is now studied on comparative and evolutionary lines.

ANTAGONISM BETWEEN SCIENCE, PHILOSOPHY AND THEOLOGY IN THE NINETEENTH CENTURY

Philosophically the significance of Darwinism lay in the fact that it helped to encourage the naturalistic or positivist tendencies of the age. For the conception of a struggle for existence and the survival of the fittest by natural selection seemed to do away with the need of employing the ideas of purpose and design in order to explain biological phenomena. It appeared to offer a purely mechanistic explanation in a region which was wont to be regarded as a stronghold of idealistic philosophers and defenders of the faith. Men of science, or at least many of them, not unnaturally bore a grudge against the more or less intolerant Churches and the philosophers who usually defended them. The middle decades of the nineteenth century witnessed remarkably strained relations between science, on the one hand, and philosophy and theology, on the other. This friction may have contributed to some extent to the exaggerated ideas which some men of science entertained about the possibility of explaining everything by means of matter and energy, or about the extent to which people could practise the art of self-denial in refraining from cosmic speculation and religious faith. Their hostility to Church dogmas and to idealistic philosophies probably did some good. It helped to encourage and intensify interest in man's earthly concerns, and in practical endeavours for the amelioration of the conditions under which the masses lived and toiled. It also helped the more intelligent members of the Churches to form more enlightened views of the world, and to adopt a more tolerant attitude towards those who belonged to other Churches or to none. In this work of general enlightenment philosophers took part, of course. For some of the philosophers were just as empirically minded, and as positivist or agnostic as the most combative men of science. But a very large percentage of philosophers were sufficiently identified with the philosophic defence of Church dogmas to rouse the antipathy of the fighting men of science. These strained relations between science, on the one hand, and philosophy and theology, on the other, may seem very strange in view of the next swing of the pendulum (which is dealt with in the Article on *Recent and Contemporary Philosophy*). But the mutual criticism during the period of hostility probably had no little share in bringing about that better mutual understanding which is the basis of those friendlier relations between them which now exist.

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THE IDEA OF GOD: AN INTRODUCTION TO THE PHILOSOPHY OF RELIGION

By

W. R. MATTHEWS

SYNOPSIS

The nature and aim of the philosophy of religion — Systematic thought on religion in ancient and modern times — In some sense, philosophy of religion a modern study — The relation of the philosophy of religion to general philosophy and its point of contact with theology — The chief problems to be discussed: (*a*) the nature of religion; (*b*) the ideas of God and the supernatural; (*c*) the real existence of God; (*d*) the theistic view of the universe and special problems arising from it, *e.g.* evil, creation, and revelation.

I The nature of religion a philosophical question which cannot be answered by psychology or sociology alone — Theories of religion: (*a*) Intellectualist: the merits and defects of this theory. (*b*) Moralist: merits and defects. (*c*) Romantic: merits and defects. Views of Schleiermacher and Otto — Positive statement of nature of religion — the tendencies of thought, will and emotion which are to be discerned in it. The basis of religious development. The relation of religion to other forms of spiritual life — " Anthropomorphism " in religion: higher and lower types — Reason and feeling in religion.

II The causes of the abandonment of all polytheistic forms of belief in the highest religion — Monotheism the only conception of the Divine which is compatible with the demands of reason and conscience — " Proofs " of the existence of God: their nature and value — The modern approach to the problem of " proof " — The three " rational " arguments — The Ontological argument stated — The vacillations of philosophy on the validity of this argument — The permanent value of the argument — The Cosmological argument stated — Criticisms and objections — The modern way of presenting the argument — The philosophy of nature and of history — The postulate of a transcendent Being required — The Teleological argument stated — The theory of evolution and its consequences for teleology — The Monotheistic hypothesis supported by " emergent " evolution — The Moral argument — Kant's influence

in modern thought — Moral development and absolute obligation — The implications of the moral consciousness — The ultimate Good — The Beautiful : its relation with the Monotheistic creed — Cumulative character of argument for Theism — The Agnostic theory untenable as theory and contradictory as a practical attitude.

III " Religion without God " in recent thought — Positivism : its defects — " Religion of Evolution " — The imperfection of any theory of religion which takes evolution as ultimate — Professor Alexander and Mr. H. G. Wells criticized — The religion of evolution requires a doubtful assumption.

IV Problems of the Divine Nature — God and the Absolute — Divine Personality — The religious needs which are met by the belief — Reasons for affirming its truth — The *via eminentiæ* — The conception of Perfect Personality — Divergent views on the nature of Personality in God — Creation — The difference between Theism and Pantheism : Emanation and Creation — Immanence and Transcendence — Degrees of immanence — Meaning of transcendence — Divergent views in recent religious thought on the subject of transcendence — The Divine Attributes : the Holiness of God : Love in God — Omnipotence : different conceptions of the meaning of this attribute — The Problem of Evil : the kinds of evil — The theory that all evil is defect of being : that it is the element of " negativity " in progress — " The best possible world " — The Problem of Good — Suffering as an element in the Divine experience : different views on this subject discussed and a possible solution suggested.

V Immortality and the Life to come — Primitive and civilized conceptions of the future life — The religious aspect of belief in immortality — The problem of mind and body — Inherent and conditional immortality contrasted — The " conservation of values " — The metaphysical and moral " proofs " of immortality — The general nature of the future life : difficulty of attaining definite conceptions — The possibility of endless progress — Revelation — The primary source of revelation and the sacred writings of the higher religions — The necessity of the conception of revelation for living religion — Reason and Revelation — The evidence for revelation — The mediæval and modern views compared — Doctrine, Dogma and Revelation.

THE IDEA OF GOD: AN INTRODUCTION TO THE PHILOSOPHY OF RELIGION

The simplest and most comprehensive definition of the philosophy of religion is that it is systematic thought about religion. Plainly we may have a great deal of religion, and religion of a high order, without any conscious and critical reflection upon it. Here as elsewhere we live first and reflect, if at all, afterwards. Men had lived together in society for many generations before they began to ask what social life really is and what kind of society would be the best. In the same way, men had acted and felt as religious beings long before the question, What is religion and why do we worship? had presented itself to their minds. But the awakening of the divine curiosity which is the motive of philosophy led almost at once to the consideration of religion. The gods were among the first subjects of critical enquiry in the early days of Greek speculation; and in the great period of ancient thought, that which embraces Socrates, Plato and Aristotle, ideas of the nature of the Divine were enunciated which have not ceased from that day until now profoundly to influence human life.

But in the strict sense the philosophy of religion may be described as a modern study. The wide extension of our knowledge of the history of the human race and the success of comparative and evolutionary studies of human beliefs and institutions have enabled us to see that religion is, in some sense, a whole. In spite of the very obvious differences which distinguished the actual religions of mankind from one another, including the utmost diversity of value, religion is something which is larger than any particular religion and raises problems which are prior to any which arise from the doctrines of any religious creed.

It need scarcely be said that the philosophy of religion is a part of general philosophy. The philosopher sets before himself the aim of interpreting the whole of experience; and therefore he can scarcely decline the task of giving some account of that aspect of man's experience which we call religion. The subject, however, is so vast and the questions raised so fundamental that there is a legitimate place for the special study of the philosophy of religion, just as there is a need for a special study of the philosophy of morals.

It may be said that if the philosophy of religion means thinking about religion it is the same as theology. This is only partly true. Theology is certainly the application of reason and reflection to religious beliefs and the attempt to state them in a systematic manner; and in this sense theology and the philosophy of religion are at one; but theology generally means the doctrinal statement of some specific religion and hence is usually concerned with the intrepretation of some real or supposed revelation. The philosophy of religion does not begin with any authoritative statement of belief or standard of religious truth; it is, in fact, part of its

duty to consider critically the idea of revelation. Thus it may be said that the philosophy of religion is a necessary prelude to theology. Perhaps one of the weaknesses of modern English and American theology is that it has often been discussed without reference to philosophy.

This distinction which we have suggested between theology and the philosophy of religion is not the same as the distinction which has often been drawn between "natural" and "revealed" religion. By many of the Scholastic theologians of the Middle Ages, above all by Thomas Aquinas, it was held that some religious truths are attainable by the unaided exercise of the human reason, while others require the disclosure of supernatural revelation before they can be known. A similar view was common in England in the eighteenth century. But we do not mean to endorse this idea when we differentiate between the philosophy of religion and theology. Our differentiation depends on method and starting-point, and could be accepted by anyone who came to the conclusion that all religion was in fact revealed.

We can now state the chief problems with which the philosophy of religion must grapple. First in logical order comes the question of the nature of religion. But this inevitably leads on to a series of further problems. We can scarcely avoid raising the question of the value of religion as an attitude of mind. This again suggests the problem of the validity of some beliefs which are associated with much, if not with the whole of religion; the ideas of God and of the supernatural in particular present themselves for critical enquiry. The question, Has religion any value? is not the same as, Does God exist? though they are closely related. It is possible to take the view, as indeed is done by some distinguished contemporary writers, that belief in God and the supernatural is not justified, but that religion is nevertheless an essential ingredient of worthy human life. The problem of the existence of God introduces us to the lines of thought which have been found satisfactory in the past by great thinkers as demonstrating His being, and requires us to estimate the present position of the arguments in the light of modern science and philosophy. Finally, there is a group of problems, each in itself of the greatest importance and complexity, which arise out of the religious or theistic view of the world: the problem of evil, the belief in immortality and the possibility and evidence of revelation. Perhaps we should add, as the final topic with which a philosophy of religion should deal, the nature of worship and its relation with man's highest good. Obviously these subjects are so vast, and the amount of reflection upon them both ancient and modern has been so extensive, that nothing but the barest sketch can be attempted here.

I

The problem of the nature of religion is considered from their special points of view by psychology, anthropology and sociology, and it has sometimes been held that the results of these sciences are a sufficient answer to the question, What is religion? This, however, is not the case. We should need, at any rate, to co-ordinate and combine the verdicts of these sciences before we could regard our problem as solved. But

further, there is a problem about religion which does not fall within the province of any positive science. When we ask, What is religion? we most commonly have in mind something beyond the question, what religion has been, what beliefs it has comprised, what function it has fulfilled in social development: we have in view the problem of its significance and its future. We desire to know what place it holds in the spiritual life of man. In Aristotle's phrase, we are concerned with the real nature which cannot be separated from its ideal development, its *telos*. The situation may be illustrated again by a comparison with ethics. Psychology, anthropology and sociology have much to say about man's moral ideas and their evolution; but at the end of their investigations we can still ask, But what *is* the good life, the life which is really good, and how is it distinguished from all other kinds of life?

Philosophical theories of the nature of religion may be conveniently classified according to the element which they take to be fundamental; and hence we obtain three divisions, corresponding to the three aspects of man's mental life, thought, will and feeling.

Intellectualist theories of religion find the essential element in it to be a kind of knowing: they regard every religion as, in essence, a view of the universe. Thus religion is closely akin to philosophy. Hegel, who held that philosophy was the supreme form of the Spirit, considered that religion was a permanent and independent activity of spirit, next in dignity and truth to philosophy. His modern Italian follower, Croce, however, holds that in this the great German thinker was mistaken, and believes that all religion is an imperfect philosophy, expressing a view of the world in images which are appropriate to art and not in concepts which are the true instruments of philosophy. In his opinion, therefore, religion is only a transient appearance and not a permanent and necessary form of the life of spirit. There is, of course, an element of truth in this view. Most religion is certainly associated with some belief or creed which claims to be knowledge about reality. But research does not support the contention that belief is the sole necessary ingredient of religion, for it would be easy to point to religious persons, both savage and civilized, in whom conscious belief or acceptance of creed is apparently absent. But the chief objection against the intellectualist theory is that religion plainly includes much more than belief about God or gods. It is an attitude of mind which, in most cases, embraces the impulse to worship and the feeling of a need for redemption.

The moralist theory of religion regards religion as primarily "practical" and concerned with the direction of the will. Most modern representatives of this view owe some kind of allegiance to Kant, who was the first to formulate the moral theory in a definite manner. According to his famous formula religion consists in "regarding all our duties as divine commands." The proposal, however, to take religion as equivalent to morality has great difficulties. Though we must admit that every religion has some effect on conduct and that, in the higher religions, this connexion with ethics is frequently very close, there seems to be a profound difference between the merely moral attitude of mind and that of religion. We might dwell once more upon the place of worship and redemption in religious life, but it is perhaps more striking to consider the question from

the standpoint of conduct. The specifically moral state of mind is a reliance upon the ability of the will to respond to the appeal of duty or of the good, an attitude well summed up by Kant's phrase, " I ought, therefore, I can." In those religions which make explicit demands for righteousness, however, the attitude of the believer is quite different. The idea of " grace " here takes the place of the idea of the power of the human will. To be righteous I must have help from a " power not myself." The formula of religion is rather, " I ought, therefore God can."

What has often been called the " romantic " view of religion stands in sharp contrast with both the intellectual and the moral, since it regards " feeling " as the basis of religion and allows great value to the imagination (as distinct from " fancy ") which other views had treated as a dangerous ally. The leader of this school of thought has been Schleiermacher, whose two books, the *Addresses to the Cultured Despisers of Religion* and the *Christian Faith*, have exercised a profound influence on modern theology. According to Schleiermacher, religion has, as such, no necessary connexion with either intellectual insight or moral conduct, but is a kind of feeling which in his first book he described as a " sense and feeling for the infinite," and later by the formula " a feeling of absolute dependence." The distinguished living theologian Professor Rudolph Otto, in his well-known work the *Idea of the Holy*, has developed a theory which owes much of its inspiration to Schleiermacher but differs in essential points. According to Otto the basis of religion is a kind of feeling, but one of a specific type which cannot be described as one of dependence simply. For this specific religious feeling Otto has coined the word " the numinous feeling." It is a kind of fear, but distinguished from mere terror. In its lowest form we may describe it by such names as " the weird," " the uncanny," while in its highest manifestations it becomes awe and reverence. The core of this specifically religious emotion and the source of its difference from every kind of mere terror or mere consciousness of our dependence, is the feeling of " creatureliness," it is the reaction of the created to the presence of the Creator. Included within this numinous feeling is the sense of mystery which is never absent from genuine religion. The Divine is, in man's consciousness, *Mysterium tremendum et fascinans*, the Mystery which causes him to shudder and yet draws him towards itself.

It is clear that each of the theories which we have briefly stated has some basis of fact, and also that each by itself gives too narrow an interpretation of the nature of religion. Even though we may doubt the statement that some belief or creed is a universal characteristic of religion, it is doubtless true that religion does tend to formulate doctrines and that the higher religions are definitely committed to some general beliefs about the nature of Reality. We have only to think of the three universal religions, Christianity, Buddhism, and Mohammedanism, and of their difference from one another, to be convinced that there is an intellectual element in any developed religion. Nor does it need proving that every type of religion affects conduct, while the religions of civilized men are all " ways of life," and associated with a more or less definite conception of the meaning of the good life for man. But any satisfactory account of religion must conceive it as embracing the whole human personality and

show how it engages the intellect, will and emotional nature when it is present in any complete way.

A positive answer to the question, What is religion? within our present limits must necessarily be somewhat dogmatic, and I must be content to state briefly a view which I have defended at some length elsewhere.[1] All the activities of man which can be described as "spiritual," the search for truth in science and philosophy, the appreciation and creation of beauty in art, the struggle for the good life in morality, appear to presuppose an essential condition. Throughout man feels, or "intuits," himself as in the presence of an Other : he is in relation with an object. Of course this "subject-object" relation is fundamental in every kind of experience, in that which is not, in our sense, "spiritual" as well as in the higher activities of mind. But in our spiritual activities there is the added feeling or intuition that the Other is in some way responsive to us. The "Other" with which we are in relation is not wholly alien to our minds, since we succeed in knowing it progressively but, so far as we can see, without limit. The "Other" is not wholly impervious to our judgments of value and ideals, for it is through action and reaction between the self and the "Other" that these value judgments have arisen; and the world is certainly not entirely resistant to our ideals. In the experience of natural beauty, which is at the root of all art, we seem to have in a very direct way a feeling that the "Other" is responding to us.

Religion, it may be held, is the complete development of this intuition of "responsiveness," which is, in some form, implicit in all our spiritual activities. Man finds, or believes that he finds, in the Other the response to his needs; not some of his needs only, as, for example, the need for truth, but to the whole body of his permanent aspirations. This would account for the fact of the development of religion, from a childlike and restricted state, that of "primitive credulity," to the highest levels of spiritual life. For man himself evolves, and as he evolves he becomes conscious of his own true nature and of needs which before had been hidden from him. The savage asks from his gods, long life, children, prosperity and the death of his enemies. The enlightened Christian finds in God the source of righteousness and the ground of truth. Thus religion from the earliest to the highest forms is a search for the satisfaction of human needs in the Other. But we shall totally misunderstand the nature of the situation if we think of the human spirit as developing by itself in complete independence of the Other. There is no such thing as the human self in isolation, there is no ego without the Other. Thus the development of religion is not only the progressive consciousness on the part of man of his own nature and needs, it is, at the same time, the progressive disclosure of the nature of the Other. Religion is both discovery and revelation.

We can now better understand a characteristic feature of religion which has often been used against it as a reproach—its "anthropomorphism." It is true that religion has always interpreted the Divine in terms of human life and experience. But the reproach is not justified when made in general terms, for clearly all human thought must be human, and if to be human

[1] *God in Christian Thought and Experience*, Chap. I.

is to be *ipso facto* wrong, then all our knowledge is false. Much religion has been justly accused of anthropomorphism in a more restricted sense, most frequently by such religious reformers as the Hebrew Prophets and Plato; but the burden of their complaint has been that men have interpreted the Divine in terms of their own lower nature, they have thought of God as "even such an one as themselves." It is important to distinguish between the kind of anthropomorphism which is the mark of a primitive or degenerate type of religion and that which is inevitable and right. The development of religion to a state above that of superstition depends upon the passing from the lower anthropomorphism to the higher.

The interpretation which we have suggested of the nature of religion will permit us to attribute a value to two modern views which, at first sight, seem contradictory of one another. As we have seen, Schleiermacher considered that a "feeling of dependence" was the essence of religion; but on the other hand, many modern authorities have held that the central element was not a feeling but a value judgment. Professor Höffding, for example, would describe religion as the affirmation that values are conserved. We are well aware that Christian conceptions of God have combined both these elements, holding that He is the ultimate Cause of all things, and also the highest Value or Good. In all religion we may, I think, discover these two elements, though of course they take different forms in the varied theologies of the world. There is always the recognition of a Reality upon which I am dependent, and at the same time the acknowledgment that this same Reality is the source of the Good, so that my "salvation" depends upon my achieving some satisfactory relation with it. The fact that religion is concerned with value makes it impossible to adopt the formula "a feeling of dependence" without qualification, for the pursuit of values, the attempt to realise some good, is without meaning unless it implies the active willing of the human agent. Thus all religious experience involves the idea of a possible co-operation with the Divine will: it is not only dependence upon God but seeking to do the will of God. We must confess, therefore, that there is a paradox within religion which we cannot completely resolve. It appears when we try to think out any of the conceptions which are prominent in every civilized religion, *e.g.* grace and freedom, God and the world, revelation and discovery. But this is no proof that religion is illusory, since all the great and permanent activities of the human spirit lead us in the end, when we try to think them out, to mystery.

We have seen that it is possible to have a religious consciousness which is not associated with any definite and explicit belief, though the religious attitude will always be found to imply some belief. The intellectual element may, so to speak, be held in solution. But we have also observed that religion, being concerned with the whole personality, is normally associated with some intellectual formulation. The ideas of religion, and particularly the idea of God, are that part of religion with which philosophy can most directly deal, and the value of religion must depend, to a large extent if not wholly, on the validity of the ideas which are its intellectual expression. We must now turn to consider the idea of God.

II

The idea of the Divine is not, of course, necessarily the same as the idea of one God. Monotheism is a comparatively late development in the history of religious thought. Some students of comparative religions have indeed held that man began with a primitive monotheism, and so great is our ignorance of religious beginnings that it would be unscientific to deny the possibility of this view. On the whole, however, it seems more probable that the religious beliefs of mankind were, in the first instance, a vague conception of nature as animated by " spirits "—that man's first creed was " animism." From this starting-point it is not difficult to conjecture how the belief in " gods " arose, and the passage from animism to polytheism may in fact be traced with a high degree of probability. Doubtless many historical causes helped to carry the faith of the more advanced sections of the human race beyond polytheism to monotheism; but two causes have been constantly and universally at work. Polytheism cannot survive the growth of the moral consciousness and the critical intelligence. The polytheistic conception of the world outrages the demand for coherence, which is the motive of the intellect, and the demand for the supremacy of one law of righteousness, which is the inspiration of the moral consciousness. A world directed by many gods could not satisfy the philosopher, nor could it give any basis for the fully conscious moral life. We may see these tendencies at work in the literature of the two peoples who have contributed most of what is valuable in our civilization—the Greeks and the Hebrews. In the former the advance from polytheism to monotheism was chiefly the work of the philosophers and was never completely successful in the sense that it never displaced the earlier forms of religious belief and practice from the popular mind : in the latter the work was done by the unique line of Prophets whose conception of the God of Righteousness culminates in the doctrine of the second part of Isaiah.

Monotheism may take more than one form. The words " Pantheism " and " Theism " have come into use by modern writers to denote two different conceptions of the Divine Being, both of which affirm the doctrine of one God. Those views are called " theistic " which hold that there is one God who is the Creator or Ground of all finite existence, Himself in some sense distinct from the world. Theism has usually maintained that God is personal and that He must be thought of as morally good or holy. The word " Pantheism " covers a great many doctrines of God which have sometimes very little in common with one another ; but the essence of Pantheism is the denial of any real distinction between God and the world. Thoroughgoing Pantheism asserts that the All is God and God is the All. The various ways in which pantheistic conceptions have been presented and worked out lead to the most remarkable differences of emphasis. Some pantheistic theories are hardly distinguishable in their consequences from materialism, while others form the basis of the most extreme mysticism, which dissolves the world of experience into mere illusion. It is significant that the pantheistic philosophy of Spinoza has been accused both of " atheism " and of " acosmism," of the denial of the reality of God and of the denial of the reality of the world.

Pantheism in every form is open to grave objections. It is clear that on

every pantheistic hypothesis the freedom, and therefore the responsibility, of finite persons must be an illusion, for they are by nature parts or aspects of the One Divine Reality. Not only does a pantheistic view tend to destroy the reality of the moral life, it tends to abolish the distinction between good and evil and affords no basis for our judgments of value. If all is Divine, then every aspect of the all must be a revelation of the Divine Reality, and the difference, which to us seems so important, between right and wrong, good and evil, must be only a distinction from our point of view, not grounded upon the nature of things. We shall have to return to this subject again when we deal with the transcendence and immanence of God.

Belief in one God Who is the Creator or Ground of all existence is a tenet which is probably comprehensible only to a relatively advanced intelligence and is capable of criticism and theoretical defence. Certain well-known arguments for belief in God have played a great part in the history of religious thought and must be briefly noticed here; but before we consider them it will be necessary to make two remarks. First, if the position which we have briefly stated in the preceding section of this essay be accepted, it is obvious that the main justification for belief in the existence of God is religious experience itself. In so far as man is a religious being, and is conscious of that responsiveness in the Other to which we have referred, he is impelled to interpret his experience and finds implicit within it some beliefs about its nature. Arguments for the existence of God are confirmations of what is, in some sense, already known. Secondly, there has been in recent years a change in the method of approach to the problem of the existence of God, and consequently in the use made of the traditional arguments. The "rational" arguments were formerly supposed, *e.g.* by Thomas Aquinas and Leibniz, to give a direct demonstration of the existence of God, a demonstration so cogent that no one who understood them could reasonably fail to be convinced by them. The modern mind, influenced by the prevalence of the scientific method, thinks in a different way. To it the question presents itself more naturally in the form: given the Universe, to find the most probable hypothesis to account for it. Among the possible hypotheses is that of Theism;[1] and the arguments may be regarded as lines of thought by which it may be shown that the hypothesis of God is more reasonable than any other. This point has been fully explained by Professor Sorley in his *Moral Values and the Idea of God*, and the change in method has been clearly stated by Professor Whitehead in his *Science in the Modern World*.

The three arguments for the existence of God which have been styled the "rational" arguments are the Ontological, the Cosmological and the Teleological. The first proceeds from the idea of God in the mind to infer the reality of God: the second argues from the existence of the Cosmos that there must be a First Cause or Ground: the third reasons from the evidence of purposiveness in the world to the conclusion that there is a purposive Mind behind or within it.

The Ontological argument first made its appearance in the writings of St. Anselm, though hints of similar trains of reasoning can be found in

[1] By Theism we mean the view that there is a personal and creative God Who is both transcendent and immanent. See Section IV. of this Article.

earlier writers. Anselm argued that even "the fool" who says in his heart that there is no God has the idea of God, for otherwise he could not mean anything by his statement. But the idea of God is the idea of "that than which nothing greater can be conceived." Now this being must exist, it must be not only *in intellectu* but *in re*, not only "in thought" but "in reality," for if it does not exist *in re* it is not "that than which nothing greater can be conceived." We could go on to conceive a being which was both *in intellectu* and *in re*. As the result of criticism Anselm made it clear that his argument was not applicable to all ideas but only to that of the absolutely infinite and perfect. It could not be used, for example, as Gaunilo suggested, to establish the existence of a perfect island. The subsequent history of this famous argument has been chequered. Rejected by Aquinas and the later mediæval theologians, it came into prominence again in the seventeenth and eighteenth centuries and formed an essential part of the systems of the three greatest thinkers of that epoch, Descartes, Leibniz and Spinoza. Kant directed a destructive criticism against it towards the end of the eighteenth century, but it was rehabilitated once more by Hegel, who regarded it as the foundation of all philosophical thought.

It cannot be said that modern thought has reached any agreement concerning the value of the ontological argument, and distinguished philosophers are still divided into those who regard it as a verbal juggle and those who hold it to be, in some form, the basis of philosophical construction. The essential element in the argument is its insistence on the idea of the perfect and the absolute as a necessary idea, one which the mind cannot help having. It may be pointed out that in all our thinking there is implicit the idea of the absolute. The conception of truth seems to involve the thought of an absolute truth, the conception of value involves the thought of an absolute value, nor would the ideas of partial truth and imperfect values have any meaning apart from the concept of that which is neither partial nor imperfect. As Descartes argued, how should we know ourselves to be finite unless we had already the idea of the infinite; and from what experience of ours could the idea of infinity and perfection be derived? Perhaps we get at the heart of the ontological argument when we put its essential thought in a different way. It is really an attempt to state in the form of reasoning two different pieces of true insight. In the first place, there is, inherent in the self-conscious individual, an intuition of his relatedness with an Other who is not wholly other, a Beyond that is within, and hence an immediate consciousness of a Reality in which the deepest and permanent needs of the self are satisfied. In the second place, all thinking and knowing depend, in the last resort, upon an ontological assumption. We must begin by taking for granted that the world is really knowable by our minds, that it is rational. This is an assumption which can never be proved, because it is itself the presupposition of every possible proof; but we may say that the existence of a rational order is verified by every advance of knowledge. The ontological argument cannot be safely dismissed as valueless, for if we do so, we are in danger of striking at the root of all thinking.

The Cosmological argument, which was formulated by Plato and elaborated by Aristotle, has generally been stated in the form of an argument

to a First, or originating, Cause. Aristotle used the idea of motion, and argued that there must be a Prime Mover who was the ultimate source of every motion in the world. This Prime Mover must be himself unmoved, since otherwise there would be needed another source of motion prior to him. The cosmological argument was the chief basis of the rational argument for the existence of God which Aquinas regarded as conclusive: it was the core of that "natural theology" which, apart from revelation, was able, it was believed, to arrive at the truth that God is and that He is one. In the exposition of the argument by Aquinas we find it presented in four distinct forms. In addition to the Aristotelian argument from motion we have the same argument stated in terms of efficient cause—there must be a First Cause—contingent and necessary being, and value or "perfection." The cosmological argument has been the common instrument of all constructive philosophies, for every attempt to "explain" the world of our experience as a whole must be some kind of argument from it, as experienced, to some ground or cause of its existence.

The traditional statement of the cosmological argument has almost invariably introduced the conception of a series which, it is argued, must have a beginning. There is a chain of causes which leads us to the First Cause, or there are a number of communicated motions or changes which lead us, on reflection, to postulate a Prime Mover. The argument stated in this manner is open to several serious objections which were pointed out by Kant. The unending series of causes or motions is, it is alleged, unintelligible: but, it may be replied, the idea of an uncaused cause or an unmoved mover is no less unintelligible. Further, the conception of cause is by no means so clear and self-evident as is assumed in the traditional cosmological argument, and the Aristotelian idea of efficient cause has almost disappeared from modern scientific theory. Again, even if the argument be conclusive, it may be questioned whether it would lead us to the thought of the God of religion. "And this all men call God" is Aquinas' formula at the end of each statement of the argument. But here he discloses his unconscious reliance upon religious experience and tradition. But that the idea of God was already present in their minds, men would not necessarily identify the first member of a series of causes with God. Kant was right when he said that the cosmological argument really presupposed the ontological argument.

If we ask ourselves whether the cosmological argument retains any value in the light of modern thought, we shall not be able to give a satisfactory answer unless we generalize the line of thought which it represents and free it from some of the limitations which have been the object of criticism. The essence of the argument is simply that "nature," "the world," or the "universe" is not a self-explanatory system: in order to interpret it we are compelled to postulate the existence of a Mind which is not identical with nature. In the more technical language of philosophy, we may say that the argument is the attempt to show a necessary transcendent reference. Plainly, this is a much more complex matter than the old cosmological argument. To state it fully would require a survey of all the possible ways of seeking to interpret the universe and an attempt to demonstrate that all of the interpretations, except that which postulates a creative Mind, are untenable. Any such lengthy investigation is far

beyond the limits of this article. We must be satisfied here to draw attention to the current tendencies of thought which are, to a degree not generally realized, in harmony with this enlarged cosmological argument.

The philosophy of nature, after being the plaything of philosophers and the scorn of scientific specialists, has within the last twenty years come to occupy the forefront of the intellectual stage. The reason for this is that science itself has found that it cannot pursue its legitimate investigations without raising some of the most profound philosophical problems, and moreover, the progress of science, particularly of physics, has seemed to throw light upon those problems. The conception of " nature " has often been taken as one which is clear and sufficient, and it has been uncritically assumed that we need no further account of the purpose of science than that it seeks to understand " nature." This was perhaps plausible so long as the old-fashioned materialism could be maintained and nature could be regarded as a mechanism. The foundations of materialism, however, have now been destroyed by the results of the research into the atom and the equally revolutionary views of space and time to which physics has been led.[1] The conclusion from this is not, of course, that scientific research can ever prove or disprove the existence of God ; but the disappearance of the conception of nature as mechanism should bring more clearly before our minds the ultimate problem of explanation. It might be argued that a mechanism is self-explanatory, since every part is determined by its relation to the whole. Even so, of course, only a very superficial reflection would be satisfied that a mechanism raises no problems, since we cannot conceive a machine which is not put together and set going. But the position into which the more recent study of nature is taking us is one in which we are almost compelled to face the question whether we are not forced to postulate Mind as the ultimate reality and conceive nature as a complex thought. To such a conclusion at least Professor Eddington and Sir James Jeans tend. The more definitely metaphysical researches of those who are professedly philosophers of nature support this conclusion. The most distinguished of these, Professor A. N. Whitehead, finds it impossible to complete an account of the natural order without assuming the existence of that which is " beyond nature " in any ordinary meaning of the word. We cannot make sense of nature, Whitehead holds, without the assistance of conceptions which transcend nature—that of " eternal forms " and that of God.

We may conclude from this brief estimate of modern tendencies in the philosophy of nature that the value of the cosmological argument is by no means destroyed, but, on the contrary, in its generalized form it is being re-enforced by scientific progress. We must, however, once more remind ourselves that a complete statement of the argument in its modern form cannot be attempted here. To do so would mean to criticize all the philosophical theories which have claimed to answer the problem of Reality without the idea of God, including those which are not directly concerned with natural science. We should have to show that whatever line you choose to pursue, whether you think of reality as " life " or as

[1] See the Articles on *The Physical Nature of the Universe*, p. 91, and *Astronomy*, p. 134.

" history," to complete your explanation you must bring in a " transcendent reference" ; the existence of Mind beyond the living beings of experience and beyond the process of history is inevitably suggested.

The Teleological argument, popularly known as the argument from design, has been the most effective with the plain man and has, in common belief, been the most severely battered by modern knowledge. In general the argument has been from the facts of order and adaptation to ends to the Source of Order and the Purposive Intelligence. Before the rise of the biological theory of evolution, the argument was most frequently founded upon particular instances of adaptation, as for example, Paley's favourite illustration, the human eye. The general acceptance of a theory of evolution has almost entirely destroyed the cogency of this type of reasoning, for we know that the eye has developed through many stages from rudimentary beginnings, and that it has been, to some considerable degree at least, determined in this development by "natural" causes. It is no longer possible to point to the eye as direct evidence of an intelligent Creator. The problem raised by the teleological argument, however, cannot be so easily dismissed. The two questions still remain : Is there evidence of a tendency in evolution itself towards the production of " values," of higher types of existence and experience ? If there is, how is this tendency to be explained ?

The answer to the first question appears to common sense to be obvious. We should agree that human life and experience is of a different and higher quality than that of the amœba, and further that there is no reason to suppose the progress in the creation of values to have finished. It may, however, be urged that these higher values are the result of accident and give us no ground for supposing, so to speak, that the universe is interested in their production. There is no complete answer to this. It cannot be demonstrated to be absurd : but such a supposition will appear to most to be improbable, and this feeling of its inherent unlikeness will be reinforced when we consider some of the consequences of the hypothesis. Knowledge is one of the values which have been evolved ; and if we are determined to believe that all value is the accidental by-product of an indifferent process we must logically include science itself among the accidental by-products. In this case it is difficult to see how science could claim to be true, or rather what the meaning of that claim would be. And if science cannot claim to be true, then we know nothing about evolution and the whole position becomes self-contradictory. The most reasonable hypothesis then is that values are not accidental by-products but integral to the process of evolution. One of the facts therefore about evolution, and obviously one of the most important facts, is that it tends to produce values.

We proceed to the second question. How shall we best explain the tendency to produce values ? The theory of evolution is at the present moment a subject of acute controversy among both biologists and philosophers, and we have to confess that in this as in other respects we are living at a period of transition. Here too the controversy is between the older theory of mechanism and other views which may be less clearly articulated but seem better to cover all the facts. The theory of " emergent evolution " has recently been made prominent by the writings of Professor S.

Alexander and Professor C. Lloyd Morgan. The concept of "emergence" is intended to meet the difficulties which the older theories of evolution encountered in connexion with the facts of the coming into existence of specifically new qualities and values. It is proposed on this theory to regard the process of evolution as something more than a mechanistic development. According to the new theory evolution has the property of bringing into existence beings which could not have been foreseen by anyone who knew the previous course of development and which, in fact, are not the mere "resultants" of prior conditions. Thus it may be said that life, consciousness and self-consciousness "emerge" in the course of evolution. The theory of emergent evolution may be welcomed as a descriptive formula. It is obviously more in harmony with the facts of experience than the mechanical theories which it hopes to displace. But no reflective person can regard it as anything more than descriptive. It would be an absurd claim, if it were made, that "emergence" really solves any problems; for the question still remains, Why has evolution this quality of emergence? The point at issue is simply this: What hypothesis will best explain this admitted tendency to produce higher qualities of life and experience? We do not solve a problem by inventing a new word for it.[1]

Once again we are brought to the hypothesis of God as the most reasonable explanation of certain aspects of the world. The teleological argument in its modern form does not profess to be a demonstration, but to be one among many considerations which converge upon the idea of God. The admission of any teleological element in evolution, of any tendency towards the production of value, suggests the thought of creative Mind. The activity of purposive intelligence would at least be an explanation, and it is not obvious that there is any other.

The rational arguments, we may conclude, have been considerably modified by the new situation created by modern science, and they will be employed in a somewhat different manner from that of the mediæval philosophers by an enlightened philosophy of religion; but they still have great value and conspire to support the theistic view of the world. They have not, however, been in fact the chief corner-stone of religious thought since Kant effected his "Copernican revolution." Since his time theologians have preferred to place in the forefront of the battle for religious faith the Moral argument.

We have already remarked that Kant criticized adversely the rational arguments for Theism in their older form. It was not, however, in the interests of Agnosticism that he conducted his campaign, but rather in order to transfer the weight of the defence of religion to the sphere of morals, "to make room for moral faith." The precise line of reasoning which he adopted is too closely identified with his own peculiar views of the nature of knowledge and of the moral consciousness to be generally acceptable to modern thinkers. In essence, however, his contention may be stated in a way which would be widely approved. If we accept the experience of our moral consciousness as it stands, we find that we are under an absolute obligation to obey the dictates of duty; the moral law

[1] For an exposition of the theory of evolution see the Article on *Biology and Human Progress*.

comes to us in the form of a "categorical imperative," that is to say, the *moral law appears to us as an unconditional demand.* It comes not with a command in the form, "Do this if you want that," but simply "Do this." At the same time, however, we cannot avoid the conviction that the life of dutiful obedience to the law of right is a rational one. But if we think out the implications of this conviction, we find that there are three postulates which we are compelled to make—God, freedom and immortality. In so far as I am a self-conscious moral being, I have the sufficient ground for belief that I am a free agent, with an unlimited destiny and under the providential government of God.

The train of reflection thus inaugurated by Kant may be pursued along somewhat different lines in view of the changed intellectual situation. We may pursue first the line of thought lucidly stated by Lord Balfour. The fact that moral ideas have evolved and that conceptions of the good life have not always been the same may seem, at first sight, to be a serious difficulty in presenting a moral argument. Reflection, however, will show that, if we still retain the conviction that we are under an obligation to pursue the good as we understand it, the evolution of moral ideas affords a ground for belief in a providential ordering of evolution. If the evolution of moral standards were the result of merely non-moral and indifferent causes, if the changing conceptions of good were nothing more than the outcome of a process which had no spiritual direction, we should be at a loss to justify any recognition on our part of absolute obligation. To understand the nature of moral ideas and the laws of their change would be to weaken their authority over us. If, however, we take it as a fact of experience, which we cannot ignore without denying our own true nature, that we are really under an obligation to obey the right as we see it and to see the true meaning of right so far as we are able, then we must believe that the development of human conceptions of the good life is a directed development, the progressive revelation of a good, which, in some way, transcends the process of evolution. Thus any theory of the development of the moral consciousness of man which does not deny, or at least weaken, the sense of obligation must be a theory which finds a moral or spiritual background to that development.

Even more clearly is a belief in God suggested and supported by a consideration of the moral consciousness in its purest forms. It seems evident that the effort of the moral life is directed towards some end : it presupposes, at least in idea, some absolute and final good in which the aspiration of the moral self would find satisfaction. If we ask what that absolute good and final end would be, we are at a loss to describe it in terms of our human experience. Whenever we try to imagine a condition of perfection as existing in time, we are conscious that we are engaged upon an impossible task, for there is always something better which could be imagined. This may be illustrated by the case of social progress. We should admit that an essential part of the aspiration of the good man is that the social life of humanity should approach nearer to its ideal. But the attempt to conceive a human society under the conditions of time and space which could be called ideal is beyond our power. It is plain that an intercourse of persons with one another, free from all defects and achieving the maximum of joy and peace and creative fellowship, is not

possible, even though our power over nature and over ourselves were indefinitely increased. If then the end of the moral life is attainable, it must be attained in the unseen and eternal sphere : but if it is not attainable, the moral life must be regarded as not fully rational, as inspired by a hope which is, by its nature, incapable of realization. If we persist in relying upon the conviction that the moral effort is both obligatory and rational, we are compelled to postulate a perfection beyond the present and visible order, some Kingdom of God or city eternal in the heavens. The principle which we have illustrated by the example of the social idea is applicable to the whole range of moral good. Wherever we come across heroic virtue, such devoted goodness as we might describe as saintliness, it appears always to be directed towards, and inspired by, a Good which can never be fully realized in time. It goes beyond any formulation of the end in merely temporal terms. It has a touch of the supernatural. On this fact of experience the moral argument for the existence of God is based.

Recent philosophy of religion has been more prone than formerly to recognize that the Good, as Plato and the Greek thinkers generally held, includes the beautiful. The interpretation of the fact that we apprehend beauty and that one of our spiritual activities is the creation of beauty[1] has, of course, been the subject of much controversy, and it would be absurd to allege that Theism alone holds the field ; but it is at least true that Theism can give an account of the matter which meets the exigencies of our experience. Here again we may with Plato find a ladder which leads from partial and imperfect beauty to the absolute Beauty. The beautiful and the sublime in nature have been the source of religious experience to " nature mystics " such as Wordsworth ; but they may also be the starting-point of an argument from analogy which has at least some force. One of the theories of the nature of beauty is that it consists in expression. If this be true, then the beauty of nature may reasonably be conceived as itself the expression of a Divine artist or poet.

The arguments for the validity of the idea of God are of a cumulative character. Modern religious philosophy does not claim to possess a single line of reasoning which alone is sufficient. It would suggest rather that among all the possible hypotheses to answer our problem of the meaning of the world and of life, the hypothesis of God, when all the data are considered, is the most reasonable. Few modern philosophers of religion would deny that there is always an act of faith in the affirmation of God's reality. We can never know that God exists in the sense that we can prove the proposition by a chain of deduction beyond cavil and theoretical possibility of error. In the end there is always an act of will which decides to adopt " the nobler hypothesis "—but it is a rational act of will and is logically no more unreasonable than believing in the existence of other people, a proposition which is itself incapable of rigid proof.

A complete statement of the argument for Theism would include a criticism of rival hypotheses such as materialism and dualism. For such criticism we have here no space, but it is necessary to mention one view

[1] The subject of " Beauty " is discussed in the Article on *The Principles of Literary Criticism*, p. 903.

which is not so much a rival hypothesis as a contention that all hypotheses are worthless. Agnosticism was the name invented by T. H. Huxley (under the mistaken impression that *agnosco* in Greek means "I don't know") to describe the standpoint that all knowledge of the nature of ultimate reality is impossible, and that we shall be wise to accept the condition of ignorance as a necessary consequence of our position as men. Much confusion is caused by the use of the word in various meanings which are not carefully discriminated. In one sense every intelligent believer in God must be agnostic, for he will readily confess that the Divine Nature cannot be completely known to man and that mystery will remain, however much the mental and spiritual powers of created beings may be improved. To hold that we have some knowledge of God is not equivalent to holding that we have or can have a complete knowledge of Him. Nor again should agnosticism mean that we are in fact ignorant of the Divine Nature, for it might be held that, though we are completely without knowledge of God now, there is a possibility that hereafter some knowledge will be attained. Agnosticism in its proper sense, that all knowledge of ultimate Reality is as such beyond our compass, is in the nature of things a contradictory doctrine. If I know that I cannot know ultimate Reality then I know enough of the nature of ultimate Reality to know that it is unknowable by me. There can be no other ground for the universal statement that Reality is unknowable than the knowledge of some quality or property of Reality which renders it unknowable. Thus, in the same breath, I am asserting both that I know ultimate Reality and that it is unknowable.

The only consistent Agnosticism is a practical attitude. I may conclude that the problem of Reality and of the meaning of life is so difficult and obscure that I shall be well advised not to think about it, or that the arguments are so evenly balanced that I should keep an open mind without embracing any positive belief. But even this practical agnosticism is not so easy to carry out as might appear. For the judgment which I form concerning Reality cannot be a merely theoretical one. My reaction to the whole of my life-experience, for example, will be affected by whether I believe in God or not, and by what kind of God, if any, I believe in. A mere refusal to think about Reality, or a genuinely balanced mind between alternatives, is not in practice a non-committal attitude. For practical purposes I have chosen the negative side of the question. It may be doubted, therefore, whether there is any rational being who has not some belief about the nature of Reality and the meaning of life which is practically potent, though perhaps intellectually incoherent and even unconscious. We are all believers, though many of us are not aware of what it is in which we believe.

III

The modern world has seen a considerable movement of dissatisfaction with the great organized and institutional forms of religion and with the conceptions of God which they have put forward in traditional creeds; but, at the same time, there has been an almost equally considerable tendency to recognize the importance of religion in human life and to

admit the need for some substitute for the worship which the ancient churches have existed to maintain. Thus the definite antagonism to all religion, which was common in the nineteenth century, is not perhaps so rife at the present day among intellectuals. For various reasons the conception of a personal God has been a chief stumbling block. We are therefore confronted with numerous attempts to retain the religious inspiration without the belief on which that inspiration has, for the most part, in the past been nourished. We must consider briefly some forms of this "religion without God."

That religion can exist without any belief in God is evident from its history, for in Buddhism, as originally taught by its Founder, there is before us a doctrine which might even be called, without much exaggeration, atheistic. It must be confessed, however, that primitive Buddhism seems to stand alone among historical religions in having no doctrine of god or spirit; and the later Buddhism has departed from its beginning in this respect. In modern times a movement which for some years had a great influence was the Positivism preached by Auguste Comte. Comte combined in his thought the two tendencies to which we have already drawn attention, that of respect for religion and distrust of theology. In his opinion the progress of human knowledge passed through three stages—the theological, the philosophical, and the "positive" or scientific. It was, he held, now plain that the only knowledge open to man is the positive knowledge of science, and that all doctrines of God must be dismissed as probably illusory. Yet the religious impulses of mankind were of the first importance and essential to social progress. He proposed therefore as a substitute for Deity the *Grand Être*, Humanity, as the object of devotion and worship. Let us transfer the religious emotions from the Deity of the traditional religion to the conception of humanity as a whole. For purposes of devotion Comte allowed the use of the images and examples of particular individuals who had contributed to progress or exemplified in a striking manner ideal human qualities.

We need not stay to describe the details of the positivist worship, since the creed and cult, as Comte conceived them, have ceased to be of any importance. The system has suffered from two defects which have become obvious in the course of discussion. First, the idea of Humanity as an object of worship opens up insoluble difficulties. Humanity, as we know it, does not appear worthy of worship, and if we amend our creed to indicate that we worship idealized humanity, we are confronted with the somewhat remarkable demand that we should worship what, in the theory of Positivism itself, does not exist and is, moreover, incapable of being adequately described. Secondly, the idea that scientific knowledge is alone positive has suffered serious damage through the progress of science itself. As we have seen, it is by no means the case that scientific theories raise no problems about the nature of things; on the contrary, research leads to those problems. There is also grave difference of opinion among students of natural science concerning the status of scientific knowledge. It is maintained by many that science can never be more than an abstract and descriptive series of formulas. There is therefore a need for philosophy in some deeper sense than a synthesis of the results of science, which was the humble rôle assigned to it by Comte. The

general aim of Positivism has not, however, ceased to secure adherents, and some of its leading thoughts, though transformed, appear in the contemporary movement for religion without God which may be described as the religion of evolution.

As we have already remarked, the conception of evolution has not remained always the same, and at the present moment there is a widespread tendency to revolt from the purely mechanistic idea and to adopt ideas of a " vitalist " or " emergent " kind. The older conception of the " orthodox " evolutionists, that the process of evolution can be regarded as, in the last resort, explicable by the laws of mechanics, has now been seriously shaken, and the " vitalist " and " emergent " theories have gained adherents both in scientific and philosophical circles. According to the former view, the evolutionary process is the development and progressive expression of a " life-force " ; according to the latter view, the process of evolution is not explicable wholly by laws of matter and motion, but has the property of giving rise to new forms of existence which could not have been predicted prior to their occurrence. The two theories are by no means identical, though they have important agreements with one another, and so far as their implications for religion are concerned, may be considered together. This change in the concept of evolution, which may or may not prove to be permanent in the sphere of science, has furnished a basis for a " new " religion. Obviously, so long as the process of evolution is regarded consistently as purely mechanical, there is little ground for finding an object of religious emotion in it, for few men would be willing to worship a machine, and probably even those few, like the man in Mr. Wells' story, *The Lord of the Dynamo*, only because they did not really think of it as a mere machine. The only worship possible in the case of a mechanical process of evolution would be that of the Maker and owner of the machine. When, however, any kind of " teleological " view of evolution is held the situation is radically changed. It is possible then to conceive religion as the service of those ideal tendencies which can be discerned within the process, as co-operation with the Life Force, or as the reaching forward in aspiration to that better life which is to be created by the process. A view of religion of this type has influenced much contemporary literature and is implied in many of the writings of Mr. G. B. Shaw and Mr. H. G. Wells.

The religion of evolution can justly claim to meet some of the requirements of the religious consciousness. It affirms the truth of the intuition that we are able to co-operate with an immanent purpose in the world, and that our good and happiness will be found in so doing. That side of Christian faith which centres upon the idea of working in the Spirit for the Kingdom of God, receives here an interpretation which is not without religious value. The religion of evolution, however, is grievously lacking in other important elements which have entered into the experience of God in the higher religions. Since the evolutionary creed rules out the conception of a Deity who is above the process, it can give no countenance to the belief that the law of righteousness is founded in eternal Reality ; if all is in flux and evolution, the very standards of judgment themselves must be involved in the stream of ceaseless change. Nor again can the religion of evolution allow the belief that there is an ultimate

Good towards which the efforts of finite beings to attain any good are tending. There can be no final vision of God in which the soul may know itself to be no longer *in via* but at last *in patria*, no longer on its pilgrimage but at last in its motherland. Nor again, can this type of religion justify any sense of dependence upon a Being infinitely greater than ourselves. The only dependence which it can recognize is a dependence upon the evolutionary process which, according to this hypothesis, is unconscious and therefore below the level of our own being.

A strange suggestion has been made by Professor Alexander. He proposes that we should attach the word " deity " to that higher type of being which, so to say, is waiting to be evolved, that with which the evolutionary process is now in travail. When the next stage is reached, " deity " will once more be transferred into the future, and worship will be directed towards the still higher yet to come. It would seem that this conception of deity labours under every kind of disadvantage, for, on this view, " deity " is both non-existent and unknown. It is non-existent because, by definition, directly it begins to exist it ceases to be deity; and it is unknown, because, according to Alexander, we have no idea what the next step in evolution will be like. It is perhaps not surprising that, so far as is known, few temples have been erected for the worship of the god who never is but always will be.

It should not, finally, escape our notice that the " religion of evolution " depends, in the last resort, upon an act of faith at least as much as the more orthodox belief in God. The upward tendency of evolution, it must be assumed, is not merely a temporary fact of the period and place in which we happen to be, but is, on the contrary, a permanent quality of the universe. It may be so, and on the hypothesis of Theism, there is good ground for believing that it is so; but simply on the basis of empirical observation there seems singularly little reason for holding so optimistic a creed, and in so far as science can make any pronouncement, it appears still to be on the side of those who believe that the universe is " running down," tending towards a state of equilibrium in which all life, and therefore all value, will be abolished.

IV

The problem of the Divine Nature has not ceased to exercise the minds of philosophers, nor will it ever cease to do so, for the Being of the Creator must always present a depth of mystery which cannot be completely grasped by created intelligences. The difficulties and apparent contradictions into which we fall when we try to elucidate the conception of God, have always been a principal argument in the hands of those who would push beyond the thought of God the Creator to the thought of the Universe or the Absolute as the ultimate Reality. Pantheistic types of thought (using the word " Pantheism " in a wide sense) have had distinguished exponents in the last generation.[1] Idealistic philosophy in the works of F. H. Bradley, Dr. Bosanquet and other followers of the Hegelian

[1] Pantheism properly means the theory that God is identical with " the All " or " the Universe." Bradley and Bosanquet are not in the strict sense Pantheists, because of their doctrine of " degrees of reality."

tradition, has been deeply sympathetic with the religious consciousness and has professed at least to be maintaining its value and legitimacy even while drastically criticizing its conceptions. According to this view, in its most coherent form, the sole reality is the all-inclusive and timeless Absolute, of which all other things are " parts " or " appearances." Thus the finite self, though not an illusion, is not finally real, and the God of religion is indeed more real than the person who worships Him, but again not finally real or true. In religion, it is suggested, we have the representation, necessarily imperfect and symbolical, of the Absolute, which is itself not a possible object of worship. The apparent paradoxes of religious faith and practice have been freely used by thinkers of this school to support the view that Theism is not in the end true. More recent movements of thought, however, have given evidence of a general reaction against Absolute Idealism. It has been objected against it that the doctrine of the Absolute, as alone completely true and real, may properly lead to complete philosophic scepticism, to the conclusion that we can have no genuine knowledge at all. The theory has also been the object of damaging attacks from the standpoint of logic, while its implications for the moral life are too obvious to need comment. We cannot here enter upon the intricate and technical discussions that have led to the retrogression of a type of philosophy which a few years ago was dominant in England, Scotland and America; we may note, however, that the way seems to be open for a positive and constructive statement of a philosophical Theism.

For modern reflection, the problem of God seems to centre in the main upon two questions—personality and creation.

The debate on the subject of Divine Personality has been confused by much misapprehension and prejudice. It has been taken for granted by critics that those who hold to the personality of God mean that, in their opinion, God is a person identical in qualities with human persons, only very much larger and more powerful. On this assumption, it has been pointed out that the universe as we know it could scarcely be conceived as the work of such a being, and the idea of the personality of God has been dismissed almost without argument. A moment's reflection should have been sufficient to convince any candid critic that this is not what intelligent men have understood by the personality of God. Orthodox Christianity, as is well known, holds that the Godhead is not a person but rather a Unity of Persons. The religious interests involved in the discussion of the personality of God are chiefly two. The most intimate type of religious experience, and most, if not all, kinds of prayer, seem plainly to involve a personal relation with God. It is difficult to suppose that prayer addressed to an impersonal principle could long be maintained. Secondly, the idea of God, if it is to be an adequate idea, must be the idea of the highest and best Being conceivable. Now personality is admittedly the highest type of concrete being with which we are acquainted, and hence we are compelled to maintain that God cannot be less or lower than personal. There is no reason why religion should object to the description of God as a " super-personal " Being, so long as it is understood that " super-personal " includes " personal " and is not a polite synonym for " impersonal."

The two "interests" of religion are, from another point of view, the chief reasons for holding the truth of Divine Personality. A total rejection of all religious experience as illusory would, of course, entirely destroy the force of the first of these two considerations. If, however, we attach some value to religious experience and therefore conceive it to have some permanent relation with Reality, the fact that a large mass of this religious experience, that which is most highly developed no less than more primitive forms, builds itself up round relations with the Divine which have the "warmth" of personal intercourse, must weigh very greatly with us. It would be a paradoxical position if religion had a content of truth but, in its highest and most effectual exemplifications, were founded upon a mere mistake.

The more strictly philosophical argument for Divine Personality depends upon a principle which in mediæval thought received the name of the *via eminentiæ*. The general idea of this method of theological reasoning has been stated most simply by the Psalmist when he exclaimed: "He that made the eye shall he not see, and he that planted the ear shall he not hear?" and by Jesus, more accurately, in His question, "If ye, being evil, know how to give good gifts unto your children, how much more shall your Heavenly Father?" It must be admitted by any thinker who allows that we can have any knowledge of God, that the highest and best things in creation will give us the analogies by which we may most adequately conceive the Divine Nature. Thus it has been urged by the mediæval Scholastics that, in attempting to determine the Divine Being by the processes of reason, we must take every "perfection," *i.e.* every valuable quality, which we find in created being and attribute it "in a more eminent manner" to the Creator. That is to say, we are to free the quality in question from all the limitations of finite existence and conceive it as perfectly realised in God. If we take the quality of "knowing" as an example, we must think of the Divine Wisdom as without limitation, unconfused, unmingled with ignorance, and needing no train of reasoning to arrive at its conclusions. It will be not "discursive" but "intuitive." We may confidently affirm that any one who denies the legitimacy of the *via eminentiæ* in some form must logically either be an agnostic or rely solely upon "revelation" for knowledge of God.

We may assume that personality is the highest form known to us of concrete and living being: in fact personality might be defined as the highest and most complete way of being alive. We may conclude then that, if God is living, He cannot be less than personal. There are, however, sufficient signs that human personality is not the most perfect form of personal life which we can conceive. Though the precise nature of personality evades accurate definition, we can enumerate certain qualities which appear to be characteristic. Personal life is the life of a self-conscious being, who is capable of directing himself by principles or ideals of conduct. A person is one who is able to know and to will. We immediately predicate personality when we feel justified in assuming moral responsibility. It is plain that personality exists in ourselves at best in a strangely imperfect form. Even the most consistent character and life are, to some extent, incoherent. Of the best man we must say that he has not shown us the full possibilities of personal life. It is, therefore,

clear that in attributing personality to God we are by no means making Him " one of ourselves " ; on the contrary, we are recognizing the existence of a Being who, while not entirely other than ourselves, surpasses and transcends us immeasurably.

The metaphysical discussions which have been evoked by the doctrine of the Divine Personality have led to many intricacies which would be out of place here ; but there is one disputed point which must be mentioned. It has been alleged that personality and self-hood are conceptions which can only be applied to limited beings, that in fact the idea of an Infinite Person is self-contradictory. In support of this contention it has been frequently alleged that there can be no self without a " not-self," and that in fact those activities which we have recognized as being the peculiar marks of personality are impossible unless there is something, some sphere of reality, from which the person distinguishes himself. Thus, both in knowing and in willing we seem to need an object which is not identical with ourselves. Three different answers to this objection have been made. (1) It has been held by religious thinkers who follow the Hegelian tradition that, though personal analogies are the best which we have for interpreting to ourselves the Nature of God, they do not take us all the way, and we must confess, in the last resort, that the Divine is supra-personal, existing in a mode which is higher than personal. (2) It has been argued by Hermann Lotze and many other Theists that perfect personality, so far from being incompatible with infinity, is only possible for an Infinite Being. " Perfect personality is in God only ; to all finite minds there is allotted but a pale copy thereof ; the finiteness of the finite is not a producing condition of this personality, but a limit and a hindrance to its development." (3) Some Theists, among them the late Dr. Hastings Rashdall, would accept the contention that the conception of a personal Deity carries with it the implications of some limitation of the Divine Nature, and would distinguish sharply between God and the Absolute. Those who take this view generally attempt to preserve the ultimate dependence of all things upon God by the conception of a self-limitation of the Divine Being.

It is not possible here to summarize the reasons which may be alleged for and against the different theories which we have now briefly stated, for it is obvious that the questions at issue cannot be discussed without raising the most complex problems. We may, however, note that it would seem essential for any Theistic belief to distinguish between God and " the universe." Whatever we may choose to mean by the word " universe," it cannot be identified with God unless we are prepared to accept Pantheism. To identify God with " the All," or the sum of things, would be to abandon the chief element in the Theistic position. In some sense, then, it would seem there must be a distinction between the Creator and the created, between God and the universe. It may be that the word " infinity " should not be applied to the Divine Nature without careful qualification. We certainly mean by God a Being whose goodness and power are without limit, but this must not be confused with the idea of infinite space or infinite time. There is a great difference between the assertion that all things depend upon God and the assertion that all things are God. The former assertion is a part of the Theistic view, the latter is not.

We are thus brought to the second of our main problems—that of creation. The relation of God to the world has been represented in many ways, of which the most important are identity, emanation, creation. As we have seen, the first of these is the conception which lies at the root of all Pantheistic philosophies in the proper meaning of that word. For the Pantheist the world and God are not two but one, they are the same Reality viewed from different standpoints. The difficulties of Pantheism have already been touched upon and we need not recur to them. Emanational theories have taken various forms, perhaps the most famous being that expounded by the last great philosopher of the ancient world—Plotinus. All theories of emanation turn upon the conception of grades of being, which proceed, not necessarily in time, from the Supreme Being, or the Absolute One, falling in value and reality as they are further removed from their Source. The essence of the emanation theory is that the world proceeds from God by a kind of necessity. It is the nature of the Divine thus to " overflow." The idea of creation is distinguished from that of emanation by the fact that it does not conceive the world as following by necessity from the Divine Nature, but as being produced by an act of will.

It is easy to exaggerate the importance of this difference between emanation and creation, for in fact the two ideas often approach one another. It need not follow from a theory of emanation that God is regarded as impersonal; and, on the other hand, it is often held by those who adopt creation as the best conception that to create is a necessity of God's nature as personal. Plainly the idea of creation lends itself to pictorial representation and has often been expressed in purely mythological terms. The analogy of the artisan making a piece of furniture, or the potter making his pots out of given material, has been taken as the guide to Divine Creativeness. The nature of the creative action of the Divine must be for ever obscure to us, and the most we can hope to attain is a point of view from which the creative action of God may be seen to be in line with something in our experience. It has been suggested by many philosophers that the work of the artist and the poet furnish us with the highest examples of finite creativeness, and hence are the most fruitful source of insight into the creativeness of God. Even this analogy, however, will take us but part of the way, and those who have made most use of it, as for example James Ward in his *Realm of Ends*, have confessed that it fails us at last.

Closely connected with the problem of creation is that of Divine Immanence.[1] The difference between Theistic and Pantheistic theories of the Divine Nature is often said to lie in the fact that Pantheism holds the Divine to be wholly immanent, while Theism holds that God is both immanent and transcendent. The statement is scarcely accurate, for any

[1] The term " immanence " (Lat., *in-maneo*) is used to express the presence and activity of God in nature and in the human mind. The term may be applied to other relations beside that of God and the world, in fact it is appropriate in any case of the association of two entities which are distinct from one another but not separate in space : e.g. the mind, or consciousness, may be said to be immanent in the body. Immanence is frequently contrasted with transcendence, but it is a mistake to suppose that the one excludes the other. On the contrary, immanence implies transcendence.

belief in immanence, if it is self-consistent, must imply transcendence. It is unmeaning to speak of immanence without, at the same time, implying that in which the Divine is immanent, and hence a distinction. As we have seen, the Pantheistic doctrine is the identity of God with the universe. The modern term immanence appears to mean much the same as the older "attribute of omnipresence." The idea of God cannot be associated with the idea of spatial limitation. That on which all things depend cannot itself be among the "things," and since space is the relation between things, or at least has no meaning apart from "things," we cannot think of God as occupying space. Consequently we cannot regard God as being present in any particular place to the exclusion of others, which is the same thing as saying that there is no place where God is not. There is, however, a difference between the ideas of omnipresence and immanence in this respect. Some writers would speak of degrees of immanence, but would hesitate to speak of degrees of Divine presence. The conception of immanence includes the idea of the manifestation of the Divine Nature. In this respect there are plainly degrees of immanence. Some aspects of creation must be supposed to be more complete disclosures of the nature of God than others. Thus, though we could not affirm that there is more of God in the human person than in the stone, we could justly assert that personality tells us more about the Creator than the stone. The doctrine of the Divine Transcendence is intended to guard against the danger of Pantheism. In the most general terms, it is the doctrine that the universe, if by that we mean the sum of finite existence, does not exhaustively display the being of God. He is beyond the greatest that we can conceive in point of power and the highest we can conceive in point of value. It should be noted, however, that the word "universe" is a very ambiguous term and should never be used without careful definition. Sometimes the word apparently implies the sum total of all that, in any sense whatever, exists, and in that case we could not affirm that God transcends the universe; more frequently the word seems to mean a whole of finite existing things, and it is important to observe that one school of contemporary philosophers at least, the Italian Idealists, would deny that there is any such whole.

An important and controversial question concerning the relation of God with the world arises from the conception of God as the Perfect Being. According to the classical and mediæval theory on this subject, the perfect must be the absolutely self-sufficient, and therefore in need of nothing beyond itself. It has been concluded on this assumption that the created world is, in no sense, necessary to God, and even that its total annihilation would make no difference to His complete satisfaction. This conception is found in its extreme form in Aristotle, who held that God was not even aware of the existence of the world, and it has played a great part in orthodox Christian theology. In recent discussions of Theism a reaction is noticeable against this view, partly on the ground that such a conception of God would be hard to reconcile with the experience of religion, but also on metaphysical grounds. The controversy has been greatly confused by being mixed up with the question of the eternity of the world. The problem is not the same. Probably no Theist would hold that the present "physical universe" is eternal in its own right; but it

might nevertheless be held that some creation is a necessity. It is argued by those who take this view that creativeness is an essential characteristic of the Divine Personality, as it is, in an indefinitely lower degree, of human personality; and, further, that it is difficult to understand how the Divine Nature can be personal unless there is postulated a created order which stands to Him in the relation of "not-self" to self. The contentions of this school have been supported by the conclusions of Professor A. N. Whitehead who, approaching the problem from the standpoint of a philosophy of nature, has been led to postulate a God as necessary for the being of the world, and at the same time a world as necessary for the being of God. On the other hand, recent movements in German theology reinforce the opposite side in this controversy. The system of Karl Barth and, in some degree, that of Rudolph Otto emphasize the "otherness" of God and would not admit any relation of God with the world, or with man, which would compromise His absolute self-sufficiency. We must be content to note this important divergence of opinion here and observe that the two opposing views carry with them important consequences, practical as well as theoretical. On the first view, which lays stress on the Divine Immanence, there will follow naturally a religion which has affinities with Humanisn and seeks the Kingdom of God partly through the promotion of human progress; on the second view, which lays stress on the absolute transcendence of God, there will be a disposition to despair of the world and of human progress, and to seek the Kingdom of God wholly in the unseen.

The dogmatic theology of our forefathers had much to say about the Divine Attributes, which were usually divided into two classes, the "metaphysical" and the "moral." Modern philosophy of religion, owing probably to its different approach, offers little systematic treatment of this subject. Indirectly, however, two topics which are part of the doctrine of the Divine Attributes have been discussed—the possibility of attributing moral goodness to God and the meaning of omnipotence. As we have seen, the conception of God is the conception not only of the Power on which all things depend, but of the Highest Value. God is the perfect Holiness. But obvious difficulties arise when we begin to think of God as morally good. Aristotle pointed out in the *Nicomachean Ethics*, that it was absurd to think of a Divine Being as exercising moral virtues such as courage, or even justice, and concluded that the Divine activity could not be that of moral goodness, but must be that of pure intellectual contemplation. The difficulty which Aristotle stated has been recast by many modern idealist philosophers into a still more formidable objection. It is said that the moral life necessarily implies a limitation and the relation of the moral being with other selves of the same order. The moral life can exist only where there are ideals to be realized and a social intercourse between persons. On these grounds it has been held that, though God, or the Absolute, is the source of all moral values and, in the end, the goal of all moral endeavour, He is Himself "beyond good and evil" and not properly described as morally good. It must be admitted that the Holiness of God cannot be precisely analogous to the virtue of a good man, and if the Divine Holiness includes the virtue of courage, for example, we are unable to understand what transformation that virtue has undergone

in the Divine Being. There is a possible view which seems to avoid this difficulty. It may be suggested that to think of goodness as consisting in the exercise of a certain number of virtues is misleading. The cardinal virtues are different aspects of goodness, but they all spring from one principle. They form a unity, because they are not independent qualities but convenient ways of describing the good life. This was Plato's conception of the virtues, and is the conception which is central in Christianity. According to the teaching of St. Paul, and indeed of the New Testament as a whole, "love is the fulfilling of the law," and every virtue is an activity of love. The attribution of love to God doubtless raises further problems, but it does not involve us in any contradiction. It may be that the conception of God as love will lead us to the further conception of distinctions within the Godhead, and furnish one of the speculative confirmations of the doctrine of the Trinity. The argument has been used by Christian theologians. Unitarians, on the other hand, would hold that the belief in the love of God does not necessarily lead to any trinitarian conclusion, since we can think of the Divine love as going forth to the creatures and finding its object in them alone.

The attribute of "omnipotence" has received more attention in recent discussions of the philosophy of religion than the other attributes because of its bearing upon the problem of evil. The crux of that problem is the apparent difficulty of reconciling the existence of evil with belief in a Creator who is at once love and omnipotent. That this old objection is still formidable is shown by the fact that so distinguished a philosopher as the late Dr. McTaggart has thought it worth while to dwell upon it in his *Dogmas of Religion*. James Ward and other writers have done valuable service in calling attention to the ambiguity of the word "omnipotent." In its original meaning, as used in the creeds, it signified "having power over all things" and was a statement of the ultimate dependence of all things upon God. In this sense it has religious value, and perhaps in this sense alone. A logical definition of omnipotence is not easy. It has been assumed by some that it includes the idea of power to do absolutely anything, including the contradictory. Thus the view has been held that God could make 2 plus 2=5. On the other hand, it has been contended that God can do all that He wills to do, but that He cannot will to do anything which contradicts His nature. It is pointed out that a mere arbitrary will is inconceivable and certainly not to be regarded as a perfection. God's will, then, must be the expression of His own nature, which is rational and good. Hence the will of God has a "formal" limitation since, being what He is, He cannot will the irrational or evil. But further, if we take the conception of creation seriously, we must recognize another limitation of the Divine power. The creation of free selves would be inconceivable unless we admitted that some limitation of the Divine power was possible. The limitation involved in creation would be a self-limitation, and not an inherent or necessary one.

The problem of evil upon which we have now touched is a standing difficulty for any philosophy of religion which is not simply destructive and critical. On any view of religion which does not regard it as pure illusion, the existence of evil must be an experience which requires consideration. This is true even if we do not adopt a Theistic interpretation

of the world, for the type of thought which regards religion as belief in the "conservation of values" or the "ultimate reality of values" must find the reality of "negative values" a challenge and a perplexity. The discussion of this problem has a long history, and it cannot be said that modern thought has added much which is distinctively new. Perhaps it has become clearer that evil falls into three categories, which are not necessarily connected with each other, and are in fact capable of separate treatment. Sin, pain and error together comprise all that we call evil; but it is obvious that the explanation of the existence of error may be quite different from that which is applicable in the case of suffering. Nevertheless the forms of evil are, in practice, often closely related, for some at least of human suffering is due to human wrong-doing and error, while sin again is partly the consequence of lack of insight into the nature of the good and the true condition of the given situation.

The theory that evil of every kind is the consequence of our finitude has been held by distinguished thinkers; and on the assumption of an optimistic pantheism it would seem most logical to conclude that evil is real only from our limited standpoint, but from the point of view of the whole is a necessary element in its perfection. That some evils arise from our limitations is plain, but the assertion that there is nothing which is really evil is scarcely acceptable to most forms of religion and is difficult to reconcile with our experience. If there is nothing which is really evil, it is argued, the efforts of unselfish men to remove evil, and the promise of religion that we can be redeemed from evil, seem alike without justification. An opinion which has been of great importance in Christian thought is that evil is non-existent, in the sense that it has no positive being. Every evil, it is alleged, is a defect of being and not an existence. Hence we cannot attribute evil to the creative will of God, since not-being cannot be created. This doctrine, which was held by St. Augustine and Thomas Aquinas, cannot be said to have solved the problem of evil, for even if we allow that all evil is defect and non-being, we have still the question upon our hands, Why should the Creator have created a world in which defect was so rife?

The idea which Augustine and Thomas adopted may be summed up in the phrase "anything exists in so far as it is good." In modern philosophy a closely related conception makes its appearance, adapted to the evolutionary mode of thought which is characteristic of the modern mind. It is one of the merits of Hegel to have emphasized the importance of "negativity" in development. Progress in a moving world occurs not in a steady upward movement, but by the overcoming of negation. Without the negation there would be no movement. This conception has been taken up by Idealists of the Italian School. The good, it is alleged, exists through the constant overcoming of its opposite. Thus truth is the continual transcending of error, and grows through the unceasing strife with imperfect and partly illusory ideas. Moral good exists only in the overcoming of moral evil. If there were no opposing movement there would be no such thing as virtue. We may allow a great measure of truth in these contentions, and agree that we cannot imagine a world in which goodness did not imply the possibility of its opposite and truth was not gained at the cost of the unremitting revision of concepts; but it is not so

easy to see what light is thrown by all this on the problem of suffering. In any case these abstract metaphysical arguments are, for most people, convincing rather than satisfying.

Leibniz is the one great philosopher who has devoted a large treatise to the problem of evil. His general answer to the question of why evil exists is that this is " the best of all possible worlds " and that any other world, though we may imagine in our ignorance that it would be better, would in fact include more evil and less good than that which actually exists. This sweeping assertion of the great optimist, and the system by which he supported it, would be accepted by few modern thinkers ; but an answer not fundamentally different has been given by more than one philosopher in recent times, among whom we may mention the late Sir Henry Jones. It is urged : look at the general features of the world and ask yourself whether, in your best moments, you would wish them altered. We cannot expect to see that every detail serves the purpose of a supreme good, but we can see that a world in which there were no hazards and hardships, in which every advance had not to be won, in which there was no adventure, would be a worse world than that in which we are. We should not wish to have everything given and no opportunity of struggle and victory. In other words, if the purpose, or part of the purpose, of the created order is the development of free personalities and the achievement by them of their own full stature through the pursuit of goodness, truth and beauty, then a world in its general structure such as ours is a requisite condition.

A paradox which has been pointed out by many writers must be mentioned here. The problem of evil, which may be called perhaps the great theoretical difficulty for a religious view of the world, is also a necessary factor in the emergence of the religious attitude. It is because men feel themselves to be weak and sinful and blind that they stretch out their hands towards a power, a perfection and a truth which will, as they hope, redeem them and raise them from their wretched state. When we reflect upon the mystery of evil we ought always to reflect upon the mystery of the Good towards which man aspires and which, as it appears, he cannot help believing to be already real.

The discussion of the problem of evil has raised the question whether suffering in any form can be held to enter the Divine Experience. Great difference of opinion on this respect has to be noticed in recent Theistic writers. It might have been expected that Christian thought, which is often said to be concentrated upon the figure of the Divine Sufferer, would have accepted the idea that suffering could be conceived as part of the life of God, while on the other hand, it might have been expected that the more pantheistic religions would have been hostile to the belief. Historically, however, this is not true. On the whole, the more philosophical Christian theology has held fast to the " impassibility " of God, to the conviction that the Divine Nature, as such, is incapable of suffering. The reason for this is that Christian thought in its orthodox forms has been deeply influenced by the Platonic and Aristotelian conception of the Divine Nature. It has assumed that God, being the perfect Being, must be absolutely complete and self-sufficient. Now suffering is always the result of a lack or want, and cannot therefore be attributed to One who is

absolutely self-sufficing. The late Baron F. von Hügel, who adhered strongly to this view, maintained, in addition to this logical argument, that religion itself would fail of its consolation if it could not believe that God was raised above the possibility of pain. On the other side, it has been urged that the problem of evil becomes more pressing than ever if we thus remove God in our thought from all participation in our unhappiness, while it is, to some extent, relieved if we believe that He bears our griefs along with us. Christian thinkers have not failed to make the further point, that the appeal of the cross is due to the conviction that it reveals to us God suffering on our behalf.

The problem is not so easily resolved as exponents of either view have suggested, and though the balance of opinion appears to be against the older view of impassibility, it cannot be said that the difficulties in the opposite opinion have been removed. Even if we found some way out of the logical difficulty of self-sufficingness as a quality of the Perfect Being, we should still have to face another problem. It can be argued that the same reasons which might lead us to hold that God shares our suffering would equally lead us to hold that He shares our sin; and this conclusion would be singularly inconvenient for any belief about God except Pantheism. If the expression of a personal opinion may be allowed, I would say that, on the one hand, it seems inconceivable that suffering does not enter, in some form, into the Divine Experience, for to deny that altogether would be to render unmeaning those assurances of the Divine sympathy which have given strength and peace to many religious souls. It would be to make God so transcendent that He would be quite different from what He is believed to be in the most poignant religious experience. On the other hand, however, it seems impossible to attribute mere suffering to the Divine Experience, for in that case we should fall into the error which Von Hügel dreaded, of debasing God in our thought to our own level of frequent frustration. The Divine Experience must be triumphant and therefore joyous; but it may be that into it there enters the suffering of the world, real but overcome.

V

There are two topics which cannot be wholly omitted in a survey of the philosophy of religion—Immortality and Revelation. The religious view of the world includes not only the concept of the Divine but of man's relation with the Divine, and this relation has been expressed in the ideas that man's destiny is not circumscribed by the present life and that he has been the recipient of Divine communication.

The ideas of immortality and of a future life are not identical. The first implies an existence which is, in some way, raised above the vicissitudes of time, the second may mean no more than that there is another temporal existence for the individual following on death. The belief in a future life is almost universal in the more primitive religions, and it may justly be claimed that there is a wider consensus for it than for belief in God. Though the pictures of the future life vary in detail, there is one common principle pervading them. The uncivilized man thinks of his life in the beyond as an extension and reproduction of the present. Nor is the

picture always of a life superior to the present one in happiness. On the contrary, beliefs are frequently of a melancholy character, and to the early Hebrew and Greek the lot of the departed was miserable compared with that of those still living. Religion does not, however, invariably give rise to a faith in personal survival. For a considerable period the higher religion of the Hebrews included no doctrine of individual immortality, but only that of the indestructibility of Israel, the chosen people of God.

When we turn to the religion of civilized men, it is important to observe that not every belief in survival of bodily death is a religious belief. The doctrine might be held as a mere fact, which could be supported by evidence but had no connexion with any spiritual end of human aspiration and no relation with worship. The belief in immortality becomes a part of the philosophy of religion when it is directly connected with belief in God.

Religious thought has been engaged for the past two centuries in a struggle with materialism, and with the more plausible surrogates for materialism which go under the name of "naturalism." The primary purpose of this struggle has been to vindicate the spiritual character of Reality and the right to believe in God; but the same warfare has been waged round the individual self and in connexion with the right to believe in his immortality. Here the difficulty for religious thought appeared more immediately pressing than in relation with belief in God, for it seemed clear that the human consciousness was dependent on the bodily organism, and every advance in physiology and psychology made this dependence more definite. There was thus apparent ground for the theory of T. H. Huxley and many Victorian philosophers that consciousness was a mere "epiphenomenon," a kind of temporary shadow cast by the brain. The development of reflection since the time of Huxley has brought into clear light the complexity of the problem of the relation of mind and body, and the fact that it constitutes one of the central enigmas of thought, hitherto an insoluble one. The Epiphenomenal theory has lost ground with serious thinkers and the prevailing views are forms either of Parallelism or Interactionism, i.e. that the two series, mental and physical, run on side by side without affecting each other, or that consciousness and the body act upon each other, neither being the creation of the other. To this development we must now add the consequences which seem to follow from the new departures in physical theory. So far as their general effect can be estimated, they lend support to the view that consciousness is fundamental in the universe and cannot be derived from or wholly dependent upon the material order. There is, we may suggest, a sharp change of direction in scientific thought. Whereas up to the end of the nineteenth century, on the whole, it lent support to the prejudice of common sense that consciousness is the product of matter, it tends now to support the opposite view.

The conceptions of immortality which have proved acceptable to religious philosophers fall roughly into two classes—inherent immortality and conditional immortality. According to the former, the human self is naturally immortal and imperishable; according to the latter it has no immortality in its own right but may attain immortality. The natural

immortality of the soul was the doctrine which the Christian Church adopted and modified. The arguments of Plato, including the famous one based upon the soul's "simplicity," were all directed towards establishing the inherent immortality of the soul. Aristotle, though he did not accept the doctrine of individual immortality, held that the "creative reason" in man was Divine and imperishable. The anticipations of the Gospel in Plato were a favourite theme of the early defenders of Christianity, and it was natural that they should assume that the Platonic doctrine was, in essence, the same as the Christian belief in the resurrection of the body. Thus it has come about that the prevailing opinion in Christian theology has been that every rational self is immortal. Recently, however, the question has been asked whether the New Testament does in fact teach the natural immortality of all souls, and whether perhaps there is not a striking difference between the Platonic conception and that of primitive Christianity. The Philosophy of Religion is not concerned with the discussion of the historical question, but it must consider the meaning of the alternative view which, it is said, the New Testament presents.

The theory of conditional immortality may be summed up by saying that it takes literally the utterance of St. Paul, "the wages of sin is death, but the gift of God is eternal life." The immortality of the self depends upon the action and choice of the self. Those who definitely and irrevocably range themselves with the lower values, the things that perish, share the mortality of that which occupied their attention and their thought. They come to an end. Those who choose the higher values, the things that are eternal, receive the gift of immortality, "the wages of going on." It is implied in this second view that there is no conclusive reason for holding that every rational being is immortal. This, however, would be disputed by some philosophies at the present time. Dr. McTaggart may serve as an instance of the persistence of the belief that human immortality can be proved on metaphysical grounds.

Few contemporary thinkers would admit that the Platonic or any other arguments for immortality are conclusive, and there would be a large measure of agreement that belief in immortality must be based upon belief in God; the best reason for holding it is that it is implied in the Theistic view of the world. Whether this is so or not is a matter of controversy; but it may be contended that any religious, and certainly any Theistic, theory of the nature of Reality must hold that there is a "conservation of values." It would appear to be very difficult to hold both that all values are conserved and that all finite persons perish, for the values which we know are all intimately related with personal life, and, so far as we are aware, can have no existence divorced from personal experience. This consideration would support the conditional view of immortality if, as seems probable, there are some selves which do not attain that degree of development which would justify us in concluding that a rational universe, in the sense of one which produced and preserved the highest sum of value, would be one in which they must continue to be.

The idea of immortality involves a great number of subsidiary ideas which are not without obscurity. For example, the problem of personal

identity is one which we should have to discuss in any complete treatment of the subject. Of still wider scope is the question whether the immortal life of those who have passed beyond death is a condition of progress towards a fulfilment, and whether the End towards which they aspire, the vision of God or the complete union with Him, is one which can be supposed to be compatible with individual existence in any sense. These discussions we must forbear to enter upon, but we must note that the fact that we may be able to find no satisfactory conclusion concerning them has little or no bearing on the validity of belief in immortality. Religion itself, when it has attained its highest point of spiritual insight, has refrained from any definite concept or image in this matter, and has been content to say, " Eye hath not seen, nor ear heard, neither hath it entered into the heart of man." We must repeat that there would be no value for spiritual religion in the conviction that life persists after bodily death, unless that life were the provision of new opportunities for the spirit in its quest for God.

All the great religions of the world, with the possible exception of Confucianism, profess to be founded upon a revelation. The record of the revelation is frequently contained in sacred writings, and the scriptures are themselves generally regarded as authoritative and as being part of the revelation. The primary source, however, of revelation is inspired persons ; in Christianity and Mohammedanism the revelation culminates in the person of the Founder of the religion, whose teaching is regarded as the highest source of the knowledge of God. The philosophy of religion is not concerned with the critical and historical enquiries which elucidate the origin of the written sources and the circumstances in which they were composed. But it is concerned with the general idea of revelation, with the possible meanings of the idea, and with the reasons which may be alleged for accepting a revelation as authentic. Revelation is an essential conception for religion. There is no living religion which is, in its own view, the mere product of human reflection ; all rest upon the supposed self-disclosure of the Divine. Nor can the most enlightened Theism dispense with the belief, since it would be a strange paradox to believe in God and, at the same time, to hold that He had in no way disclosed Himself to His creatures.

Religious thought has been haunted by the distinction between reason and revelation. Sometimes these have been set in opposition to one another, but more frequently they have been regarded as separate but co-ordinate sources of Divine knowledge. The theology of the Middle Ages in Christendom spent much thought upon the relation of the authority of Revelation and the power of the unaided human reason. The differentiation between " natural " and " revealed " religion is still common. As we have already seen, according to Thomas Aquinas certain truths concerning God, such as His existence and His unity, are open to the mind of man apart from any revelation. They can be demonstrated by the speculative intellect : they have in fact been demonstrated by Aristotle. Certain other truths, such as the Incarnation, the Redemption of man, the creation of the world, and the Trinity could not have been discovered by human reason. Now that they are authoritatively revealed they can be shown to be not contrary to reason, though above it. Certain

consequences follow from this theory. In the first place, it seems that the substance of revelation is the same in kind as that of the knowledge which the intellect acquires by its own independent operation. Revelation, so to speak, steps in where reason leaves off, and supplements man's imperfect supply of truth about God with more truth about God. We should observe, however, that Aquinas recognizes another function in Revelation. It conveys the truths of " natural religion " to those who, from lack of faculty or opportunity, would not otherwise have known them. A conception practically identical with this was adopted by Bishop Butler, according to whom a part of the office of Revelation is to be a " republication of natural religion." In the second place, a consequence concerning the credentials of revelation must be pointed out. Since the essential nature of revelation is to add to what reason can tell us, the evidence of revelation cannot be its conformity to reason. Our ground for accepting it must be sought in " external evidence," in miracle and the fulfilment of prophecy.

Various causes have been at work to produce a movement away from this position in modern thought. The fact that the value of alleged miracles as evidence of revelation has been disputed, and the new critical conclusions concerning the nature of prophecy, have played an important part; but perhaps of even greater influence have been considerations drawn from the nature of religion itself and the study of the relation of authority to reason. The old division between natural and revealed religion has been questioned by many writers, notably by Professor Clement Webb, and the increasing knowledge of the phenomena of religious experience has reinforced the disposition to abandon the traditional standpoint. No part of the philosophy of religion has been so little investigated as the idea of revelation, and it must be confessed that we await a systematic treatment of the question. The main lines, however, of a modern view are taking shape. It would discard the assumption that the primary content of revelation is " propositional " knowledge, a collection of miraculously communicated statements about Divine things, or supernaturally imparted philosophy. It would return to the Biblical conception of revelation as the self-disclosure of God in human experience, in the lives of persons. The theological doctrines, and the literary expressions of this experience, are not themselves the revelation but are more or less adequate interpretations of it. In this way it would be impossible to divide religion into " natural " and " revealed," for all religion would be revealed, and at the same time all would be a proper object of rational criticism and valuation.

If this theory were adopted, it would be necessary to extend the notion of revelation beyond the borders of religion in its narrower sense and include all apprehension of spiritual values, moral and æsthetic as well as " religious," within its scope. The fact that much religion is mixed with superstition and positive evil would be explained on the ground that revelation, being always through persons, must be conditioned by the capacity of the persons; the human element in the revelation will always be present. The Divine light will always be distorted by the human medium; in One alone, according to Christian belief, has the human personality been the adequate instrument of the Divine self-revelation.

In this manner we might conceive the whole spiritual development of man as a revelation of God, and might proceed to trace the line which seemed to lead most directly to revelation's highest point. Some such argument would be used by a modern believer in a special and final revelation to justify his belief that there has appeared in history a disclosure of the Divine which has supreme authority. Into these domains it is scarcely the duty of the philosophy of religion to enter. It has fulfilled its task when it has taken us to their boundary and pointed to the territory which remains for the enquiring spirit to explore.

BIBLIOGRAPHICAL NOTE

The literature of the subject is immense, and a complete list of essential writings would cover the whole period of civilization—in the West at least from Plato onwards. The following books are given as examples of modern discussion which the reader will find useful.

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THE PHYSICAL NATURE OF THE UNIVERSE

By

J. W. N. SULLIVAN

SYNOPSIS

This Article begins with the fundamental physical concepts introduced into science in the seventeenth century and describes their successful application to a description of a variety of phenomena. The discovery that these concepts were inadequate is then shown to have been brought about by the fruitless attempts to construct a mechanical theory of light, and by the experimental work that led to the dissociation of the atom into charges of electricity. Cognate discoveries, e.g. Radio-activity and X-rays, are also mentioned, and the electric theory of matter is developed. Further analysis of matter is shown to make a still more fundamental revision of scientific concepts necessary, and the reader is introduced to the modern Quantum Theory and to the new theories of atomic structure. It is shown that science has abandoned the ideal of explaining phenomena in terms of the *familiar*. The abstract character of the new theories is emphasised. The simultaneous analysis of space and time conceptions, culminating in the generalised Theory of Relativity, is also described, and an account is given of the Theory of the Finite Universe and of the recent attempts to extend still further the range of Relativity Theory.

THE PHYSICAL NATURE OF THE UNIVERSE

§ 1

The science of Physics has often been presented to an admiring world as the ideal science. It seems to fulfil all the criteria that make an enquiry truly scientific. Thus it rests upon observation and experiment; all its terms are clearly and exhaustively defined; and it reaches its conclusions by the impeccable method of strict mathematical reasoning. Compared with it all other sciences are, in one respect or another, imperfect. Thus astronomy, although it rests upon observation and employs mathematical reasoning, knows nothing of experiment. Men cannot experiment with the stars. The astronomer cannot handle and control his material with the facility that the physicist enjoys. The science of chemistry, although most firmly rooted in observation and experiment, makes comparatively little use of mathematical reasoning, and some of its fundamental concepts are not yet, perhaps, entirely free from obscurity. Biology is still more imperfect in these respects, while to call psychology, ethnology, economics, and so on, scientific is to express an aspiration rather than an achievement.

It would seem, therefore, that the best exhibition of the procedure of science and of its ultimate aim is to be found in the science of physics. Physics, one would suppose, is the study which presents the scientific method in all its purity. But when we study the descriptions of the various phenomena covered by the science of physics we do not find that any one ideal of " explanation " has been consistently adopted. Different kinds of explanations have been fashionable at different times. It would seem, on a broad survey of physics, that science does not yet know its own mind. Einstein's theory differs from Newton's not only in mapping more accurately the region of phenomena surveyed, but also in the fact that the map is constructed on entirely different principles. The atom of modern physical theory is not only a more complicated entity than the atom of the Victorians, but it is, as an intellectual construction, based on entirely different concepts. Physics began, and for a long time continued its career, by trying to explain phenomena in terms of familiar notions. Thus Newton's " forces " of attraction and repulsion had their psychological origin in our sensations of muscular effort—of pulling and pushing. The " electricity " of the early physicists was conceived as a " fluid." The " atom " of the Victorians was analogous to a tiny grain of sand. Modern physics has given up this criterion of familiarity. Many modern physical theories consist in establishing mathematical relations between entities which can be logically defined but which are quite unimaginable. It is for that reason that these modern theories cannot be " pictured."

Although physics has, in very important respects, profoundly changed, it remains mathematical in character. The primary entities used in physics are all capable of mathematical definition. Indeed, entities which cannot be defined mathematically would not be adopted in physics. We may say that physics is an adventure. It is an attempt to describe Nature, or certain parts of Nature, mathematically. In this respect the science of physics has always been self-consistent. But the primary entities to which the mathematical method is applied have changed out of all recognition of recent years. In that sense the science of physics has truly undergone a revolution. To understand this revolution we must understand the causes that have brought it about.

Modern physical science is popularly supposed to have begun with Galileo. Scholars can show that there was considerable activity, of a kind that we should have to call scientific, before Galileo, but it remains true that Galileo was the first to isolate clearly certain fundamental scientific ideas, and the first to present them forcibly to the mind of his time. Galileo's greatest contribution to the scientific outlook consists in his analysis of the notion of motion. He claims to have been the first to realise that motion should be treated mathematically. Even so simple a matter as the acceleration of a falling body had never been stated clearly before. People realised, of course, that a falling stone moves faster and faster, but it does not seem to have occurred to them to measure the rate of increase of the motion. Galileo understood this perfectly. As he says: "It is requisite to know according to what proportion such an acceleration is made; a problem that I believe was never understood hitherto by any philosopher or mathematician, although philosophers, and particularly the peripatetics, have writ great and entire volumes touching motion."

How did Galileo come to conceive the idea of treating motion mathematically? How, in fact, did the notion ever arise that Nature is a vast mathematical machine? The notion was not a part of the orthodox Aristotelianism of the Middle Ages, although it had occurred to certain exceptional minds, such as Roger Bacon and Leonardo da Vinci. It seems, as a matter of historical fact, that the notion came about as a result of certain philosophical speculations. There has always been a certain type of mind which is prone to find in mathematics the key to all things. Some of the manifestations of this general attitude are decidedly puerile, as we see when numerical interpretations are applied to the prophetic books of the Bible. The Great Pyramid imbecilities and some of the Shakespeare-Bacon controversies are manifestations of the same tendency. Even some very great men have been impressed by the mystical significance of mathematics. Thus, St. Augustine tells us that God created the world in six days, because six is the perfect number (being the sum and also the product of the first three numbers), and six would still be perfect even if the work of the six days did not exist. We may dismiss these notions as mere fantasies, but it cannot be denied that the general attitude played a great part in the creation of science. Kepler, one of the really great creators, thought that Nature is essentially mathematical. He did not

merely believe that phenomena could be described mathematically; he believed that the cause of the phenomena existing at all was that they fulfilled certain mathematical relations. Galileo did not go quite so far as this, but he did not always feel it necessary (he tells us) to verify his mathematical deductions by experiment. We realise now, of course, that a mathematical deduction must always be checked by experiment. This is not because mathematical reasoning is in itself imperfect, but because the premises from which we start may not correspond precisely to the facts. Newton recognised perfectly the issues involved when he said that the attempt to describe Nature mathematically is an adventure which may or may not be successful. If it breaks down (he said), we must try another method. The method has, as a matter of history, been enormously successful, but we must not assume that Nature is necessarily a mathematical machine, although it is quite likely that we shall be unable to understand it if it is not.

Galileo, as we have said, was the first to make the notion of motion clear and precise enough to be treated by mathematical methods. In doing so he also had to make a precise mathematical concept out of the notion of Time. It was his grasp of the mathematical nature of time (as a uniform flow) that led him to devise more accurate clocks.

Galileo believed that the really important properties of the world are those that can be mathematically defined. Thus, things differ from one another in size, shape, weight and motion, and all these four properties can be described mathematically. The whole world was built up, he believed, out of atoms, and these atoms had the four properties mentioned. Differences of motion are produced by *force*, but Galileo does not tell us what force is. He leaves the notion of force something of a mystery. His conclusion is that atoms, acted on by forces, produce, by their combinations, the whole material universe. And in this conclusion we have presented, in essence, the problem that was to dominate physics for nearly two hundred years. We may say, roughly, that the science of physics came about as an attempt to solve one great problem—to show that everything is explainable in terms of the motions of little particles. In these terms there had to be explained the different states of matter—solid, liquid, gas. There had to be explained the phenomena of heat, light, sound, magnetism and electricity, and a host of other phenomena, besides the great omnipresent fact of gravitation. As we shall see, the effort has been partly successful and has, in part, been definitely abandoned.

§ 3

The scientific adventure began, as we have seen, by assuming that the only properties possessed by the real world are such properties as size, shape, weight and motion—all of which can be described mathematically; that is to say, they are all quantitative properties. But we are aware of aspects of the world that are not obviously quantitative. We are aware, for instance, of colours, sounds, odours. What do these perceptions tell us about the real world? This question really belongs to philosophy, and different philosophers have given different answers to it. But science has generally assumed that these non-quantitative properties are not part of

the real, objective world. The point of view is well put by Galileo, who was the first to make it explicit. He says:

"But first I want to propose some examination of that which we call heat, whose generally accepted notion comes very far from the truth if my serious doubts be correct, inasmuch as it is supposed to be a true accident, affection and quality really residing in the thing which we perceive to be heated. Nevertheless, I say that indeed I feel myself impelled by the necessity, as soon as I conceive a piece of matter or corporeal substance, of conceiving that in its own nature it is bounded and figured in such and such a figure; that in relation to others it is large or small; that it is in this or that place, in this or that time; that it is in motion or remains at rest; that it touches or does not touch another body; that it is single, few, or many; in short by no imagination can a body be separated from such conditions: but that it must be white or red, bitter or sweet, sounding or mute, of a pleasant or unpleasant odour, I do not perceive my mind forced to acknowledge it necessarily accompanied by such conditions; so if the senses were not the escorts, perhaps the reason or the imagination by itself would never have arrived at them. Hence, I think, that these tastes, odours, colours, etc., on the side of the object in which they seem to exist, are nothing else than mere names, but hold their residence solely in the sensitive body; so that if the animal were removed, every such quality would be abolished and annihilated. Nevertheless, as soon as we have imposed names on them, particular and different from those of the other primary and real properties, we induce ourselves to believe that they also exist just as truly and really as the latter. I think that by an illustration I can explain my meaning more clearly. I pass a hand, first over a marble statue, then over a living man. Concerning all the effects which come from the hand, as regards the hand itself, they are the same whether on the one or on the other object—that is, these primary properties, namely, motion and touch—but the animate body which suffers that operation feels various affections according to the different parts touched, and if the sole of the foot, the kneecap, or the armpit be touched, it perceives, besides the common sense of touch, another affection, to which we have given a particular name, calling it 'tickling.' Now this affection is all ours and does not belong to the hand at all. And it seems to me that they would greatly err who should say that the hand, besides motion and touch, possessed in itself another faculty different from those—namely, the tickling faculty; so that tickling would be a property that exists in it. A piece of paper, or a feather, lightly rubbed on whatever part of our body you wish, performs, as regards itself, everywhere the same operation—that is, movement and touch; but in us, if touched between the eyes, on the nose and under the nostrils, it excites an almost intolerable tickling, though elsewhere it can hardly be felt at all. Now this tickling is all in us and not in the feather, and if the animate and sensitive body be removed, it is nothing more than a mere name. Of precisely a similar and not greater existence do I believe these various qualities to be possessed, which are attributed to natural bodies, such as tastes, odours, colours and others.

But that external bodies, to excite in us these tastes, these odours, and these sounds, demand other than size, figure, number and slow or rapid motion, I do not believe; and I judge that, if the ears, the tongue and the nostrils were taken away, the figure, the numbers and the motions would, indeed, remain, but not the odours, nor the tastes, nor the sounds, which, without the living animal, I do not believe are anything else than names, just as tickling is precisely nothing but a name if the armpit and the nasal membrane be removed."

Thus, Galileo maintains that the characteristics of the real world are quantitative, and that our perceptions of qualitative differences are merely the way our minds react to certain quantitative differences. Thus, colours, as such, do not enter into the scientific scheme. Light is a wave-motion in the ether, and different colours correspond to different wave-lengths. It is the wave-length with which science is concerned. It is for this reason that a colour-blind man, or a man born blind, can understand perfectly the whole science of optics.

It is to be noted that in this passage Galileo assumes rather than proves that perceptions of weight, motion, etc., are of an altogether different kind from our perceptions of colour, sound, etc. He assumes that the first class of perceptions reveal to us an objective reality, whereas the second class does not. He imagines that weight, motion, etc., would still exist "without the living animal." This is an assumption with which many philosophers disagree. The distinction is important, however, as making clear the limits within which science is confined by its method. Science is confined to the quantitative features of the world, but there is no real reason to suppose that everything science neglects is less real than what it accepts.

§ 4

Although the theory that matter is composed of small indivisible particles was not given precise shape until the nineteenth century, the atomic theory, in a more or less vague form, had been held by many scientific men from the time of Galileo onwards. But the first man to make the theory quantitative, and therefore a valuable instrument in research, was Dalton, who applied it with considerable success to the phenomena of chemistry, thus giving that science a quantitative basis it had hitherto lacked.

Until quite recent times the atom was conceived as a small, hard and probably spherical piece of matter. The word "atom" is properly applied only to the ultimate particles of a chemical element. The ultimate particle of a chemical compound which is, of course, formed of the combination of two or more elements, is properly termed a "molecule." There are about ninety distinct chemical elements in the world, and every other substance is formed out of combinations of two or more of them. Thus, sodium is a chemical element and so is chlorine. But sodium chloride, which is common table salt, is a combination of sodium and chlorine. Water is a combination of hydrogen and oxygen. An ultimate particle of water—a molecule—consists of two atoms of hydrogen united

with one atom of oxygen. For the purpose of understanding these, and similar facts of chemistry it is not necessary to conceive the atom as being anything more than a small particle, analogous to a very tiny grain of sand. It is not necessary to attribute *structure* to the atom. Also, as we shall see, this simple conception suffices to explain many physical phenomena. It is only certain recent researches which make it necessary for us to regard the atom as an extremely complicated structure.

The three states of matter—solid, liquid, gaseous—are readily explained on the basis of the atomic theory. In a solid we may regard the atoms as being fixed in position. They may be able to vibrate about these fixed positions, but they have very little freedom to wander about. For this reason a solid preserves its shape. In a liquid the atoms have more freedom of movement; they can slide about over one another. Hence a liquid easily takes the shape of any vessel into which it is put. Nevertheless, the atoms of a liquid are sufficiently closely bound together to ensure that the liquid shall remain of the same *volume* into whatever vessel it may be put. In a gas, however, the atoms have achieved their maximum degree of freedom. A gas consists of a number of atoms, or molecules, flying about in all directions with all velocities. There is no natural limit either to the size or the shape of a gas. A gas simply expands until it fills whatever vessel contains it. Thus, the differences, in broad outline, of the three states of matter are readily explained by the atomic theory.

The agent that brings about the change from the solid to the liquid and from the liquid to the gaseous is heat. It follows, on this theory, that heat increases the atomic and molecular motions of bodies. It is easy to go further and to assume that heat actually consists of these motions. This theory, which is now the accepted theory, was probably held by Galileo, and was certainly held by Newton, Hooke, Boyle and others. But during the eighteenth century this theory—that heat is a mode of motion—fell into disrepute, and was replaced by the *caloric* theory of heat. According to this theory, heat is a fluid, called "caloric," whose union with bodies raises their temperature. This theory was always unsatisfactory. It was so unsatisfactory, in fact, that men of science were always tinkering with it in order to meet various objections. Thus, the original form of the caloric theory explained the fact that bodies expand on being heated by saying that the particles of caloric that enter into the body repel one another and thus stretch the body out. But it was pointed out that the expansion rule was not universal. Thus, water expands on *freezing*. How is this to be explained? The calorists explained it by modifying their original assumption. They now said that caloric combines *chemically* with the body. Now the volume that results from a chemical combination cannot be predicted. Thus the calorists got out of the difficulty by saying that anything might happen. This is unsatisfactory. A scientific theory that only lives by undergoing successive arbitrary modifications must be regarded with suspicion.

But the death-blow to the caloric theory was given by Count Rumford in 1798. While engaged in boring brass cannon at the military arsenal at Munich, he found that the metallic chips thrown off were very hot. This heat was obviously produced by friction, and he undertook experiments to find out whether there was any limit to the amount of heat that could

be produced in this way. He found no limit. It appeared that heat could be generated by friction inexhaustibly. This result was sufficient to disprove the caloric theory. As Rumford said: "Anything which any *insulated* body or system of bodies can continue to furnish without *limitation* cannot possibly be a *material substance*." The only thing that can be generated indefinitely in this way, Rumford concluded, is motion. He decided, therefore, that heat is a mode of motion. Numerous other experiments confirmed this conclusion, and it is now universally accepted that the heat of a body is due to the motion of its constituent molecules.

A very interesting result can be deduced from this theory. If heat is a manifestation of the molecular motions of a body, it follows that, if the molecular motions cease, the body possesses no heat at all. We are accustomed to suppose that a body can get colder and colder, just as it can get hotter and hotter. But if heat depends on molecular motions, then, in the absence of those motions, there can be no heat. A body in this state is said to be at the absolute zero of temperature. This temperature, it can be shown, is the same for all bodies, and theoretical considerations enable us to say what this temperature is. Measured on the centigrade scale, the absolute zero is 273° below zero, the ordinary centigrade zero being, of course, the temperature of melting ice. Thus, the absolute zero of temperature is 273° below the temperature of melting ice, or 373° below the temperature of boiling water, since water boils at 100° on the centigrade scale. The absolute zero of temperature can be very nearly attained by modern laboratory methods. Temperatures of about one degree above the absolute zero have been reached. At such temperatures all known gases become solid, as we should expect, since their molecular motions have almost entirely ceased.

The range of temperature in the universe extends from the absolute zero to the temperature of the central portions of the stars. This latter temperature is estimated to be many millions of degrees. The great bulk of the matter in the universe is, from our point of view, exceedingly hot. It is only the very cold parts of the universe, those where the temperature is very near to the absolute zero, that can support life.

The fact that the molecules of a body are normally in movement can be demonstrated by what is called "The Brownian Movement." In the year 1827 an English botanist named Brown observed that very small particles suspended in water were in a state of constant agitation. For many years this discovery attracted no particular attention; it was put down to inequalities of temperature or to vibration. But a series of careful experiments finally showed that the effect really was remarkable and could not be accounted for by any ordinary means. The explanation was given by Einstein. He showed that the phenomenon was produced by the molecular movements of the water. The small particles, suspended in the water, must be perpetually struck by the moving molecules of water. As the molecules move indiscriminately in all directions, these collisions would usually cancel out. But it would sometimes happen that more molecules would strike the particle on one side than on another, and thus knock the particle a little forward. The next instant the direction of maximum impact would be changed. And thus we should obtain the incessant and highly irregular movements noticed by Brown. When Einstein's

theory was experimentally checked, it was found to be fully confirmed. Thus, we may say that the Brownian Movement is a direct revelation of molecular movements.

Further support to the doctrine of molecular movements is given by the success of the Kinetic Theory of Gases. According to this theory a gas consists of a number of molecules flying about in all directions. As the temperature of the gas increases, the velocities of the molecules increase. On the basis of this theory the properties of gases can be worked out and are found to be in accordance with the experimental evidence. Here is another proof, therefore, of the truth of molecular motions.

§ 5

We have seen that the notion that matter is composed of small ultimate particles is sufficient to explain a fair range of phenomena. But, in the course of these explanations, the notion of the atom has not been made very precise. It has not been necessary to make it so. It has been sufficient to imagine the atom, vaguely, as a small, hard and possibly spherical body. But this small body has been supposed to be of uniform constitution throughout. We have not supposed that it possessed a *structure.* A whole new realm of thought, which science cannot yet fully survey, was thrown open, when it was found that this simple conception was inadequate.

The first indication that atoms were not the simple things they had been taken to be came with the discovery of the Periodic Table of the Elements. Atoms, it must be remembered, were known to be of different weights. All atoms of the same element were of the same weight, but the atoms of different elements differed in their weights. The chemists, by laborious and accurate experiments, had determined the relative weights of different kinds of atoms. Thus, it was known that an atom of oxygen weighed sixteen times as much as an atom of hydrogen. The elements could be arranged in the order of their atomic weights, beginning with hydrogen, the lightest of the elements, and ending with uranium, the heaviest known element. When the elements were arranged in this way it was found that they fell into more or less well-defined groups. A group of heavy atoms would be found to repeat, fairly closely, the chemical and physical properties of a group of lighter atoms. This sort of repetition ran all through the table. At regular intervals atoms appeared which seemed to be, judging from their properties, more complicated versions of atoms which had appeared earlier in the table. The physical and chemical properties that characterised any given atom occurred periodically at intervals throughout the table. This similarity of properties suggested a similarity of structure. It began to be suspected that atoms were not merely simple particles, but entities possessed of a more or less complicated structure. Another twenty-five years was to elapse, however, before this surmise received experimental justification.

Between the years 1895 and 1900 a series of extraordinary experiments showed definitely that the atom is not a simple entity. The first group of these experiments was concerned with the electric discharge in a vacuum

tube. If two metallic plates are fixed inside the two ends of a glass tube which has been exhausted of air and these two plates are then connected to a source of electricity, a somewhat complex phenomenon occurs in the tube. The chief part of the phenomenon, however, consists in a stream of something coming from the negatively electrified metal plate. It can be shown that this stream travels in straight lines, for if an obstacle be placed in its path a clearly-defined shadow is thrown on the far end of the glass tube. If a magnet be brought near the tube, the direction of the stream is deflected. It was proved that the rays constituting the stream actually carry negative electricity with them and, further, that they possess the extraordinary property of being able to pass through thin sheets of metal. In 1897 J. J. Thomson put forward the theory that these rays consisted of electrically charged particles, but that the particles, as their penetrative power proved, were much smaller than ordinary atoms. The next step was to determine the precise size of these little particles. This was done, with the extraordinary result that they were found to be nearly two thousand times smaller than the lightest known atom—namely, the hydrogen atom. These little electrified particles were called "electrons." Further experiments showed that, wherever and however they were obtained, all electrons were exactly alike. Here, then, it was conjectured, were the real foundation-stones of the material universe. The theory came into being that all material atoms are composed of electrons.

But in the meantime a very interesting discovery had been made respecting the nature of these electrons. We have described them as "electrified particles." Now J. J. Thomson had shown, some years before, that when a body is charged with electricity, that body behaves as if its mass were increased. It is as if the electric charge has a mass of its own. How much of the mass of an electron is due to its electric charge? This question could not be answered until the mass and the electric charge of an electron could be measured separately. This was finally done and the result was bewildering. It turned out that the *whole* of the mass of an electron was due to its electric charge! The electron was nothing but electricity. There was no "ordinary matter" there at all. The theory that matter is composed of electrons, therefore, really meant that matter is built up out of "disembodied charges of electricity." The theory seemed to make the whole world of matter completely unsubstantial. The theory could only be assimilated by making our notion of "matter" somewhat more abstract. We had to get rid of the notion of "substance" and replace it by the notion of "behaviour." Anything that behaved like matter, anything, in particular, that manifested the cardinal property of matter—namely, inertia—was fitted to play the rôle of matter. Electrons possess all the necessary properties. The fact that they are called "electric charges" instead of "material particles," only means that they possess other properties in addition.

It is evident, however, that electrons, by themselves, are not sufficient to build up atoms of matter. Atoms are electrically neutral, whereas every electron is charged with negative electricity. Further, electrons, all being negatively electrified, repel one another and an assemblage of them could not be stable. We must assume, therefore, that the electrons in an atom are somehow associated with a charge of positive electricity. Such a

combination could be stable, and would also account for the fact that an atom is electrically neutral.[1]

The next step was to determine the way in which these constituents are arranged in the atom. After one or two unsuccessful attempts had been made, Sir Ernest Rutherford suggested an arrangement which has had a great measure of success. This was the famous theory of the atom as resembling a "miniature solar system." The positive charge was supposed to be located at the centre of the atom, while the negative electrons, like so many planets, circulated round it. In every case the central positive charge is just sufficient to counterbalance, electrically, the sum of the electrons circulating round it. The differences between different kinds of atoms were explained by differences in structure. Thus, a hydrogen atom consists of a positively charged nucleus with one electron circulating round it. The next atom in the table of the elements—helium—has two circulating electrons. The next atom has three, and so on, until we reach uranium, which has ninety-two circulating electrons.

Such is, in broad outline, Rutherford's theory of the atom, although, when worked out in detail, various complications arise. Thus, it was found that the positively charged nucleus must be given a complex structure, except in the case of the hydrogen atom. The nucleus of the hydrogen atom is taken as the unit of positive charge, and is called a "proton." The nucleus of the helium atom, however, does not consist of two protons, but of four protons combined in some way with two electrons. The nuclei of other atoms are still more complicated. Also, the orbits of the circulating electrons in an atom cannot be assumed to be simple circles. Some of them are very markedly elliptical. Further, they do not all lie in the same plane.

This model of the atom, although well confirmed by experiment, was not at all satisfactory to the mathematicians. According to the accepted laws of electrodynamics, which had been thoroughly well confirmed over a wide range of phenomena, such an atom could not be stable. The revolving electrons, it could be shown by mathematical calculations based on the accepted laws, would necessarily radiate energy and approach ever more closely to the nucleus. Finally, they would fall into the nucleus and the whole atom would vanish in a flash of radiation. On the basis of the accepted laws of nature, therefore, such an atom was impossible. It so happened, however, that a new and very strange theory of radiation had been proposed by Max Planck some years before. He had come to the conclusion that the heat radiated from a hot body was not radiated in a continuous manner, but in little jerks, or *quanta*. Similarly, the heat falling on a body was not absorbed continuously. Planck imagined that this curious effect was due to some sort of resonating apparatus in the atoms

[1] If a piece of glass be rubbed by a piece of vulcanised india-rubber a certain degree of force is required to separate them and, if not too far apart, they are found to attract one another. They have been electrified by friction. In general, any two bodies can be made to exhibit the same phenomena. But it will be found that one of these bodies will repel the glass and attract the rubber, and that the other will repel the rubber and attract the glass. Hence there are two kinds of electricity. They are called positive and negative. Like charges (*i.e.* both positive or negative) repel one another. Unlike charges attract one another.

of bodies, but later developments of the theory showed that the effect was not brought about in that way at all, but was a revelation of the actual nature of radiant energy. Radiant energy is, in its very nature, atomic. This conclusion applies to all forms of radiant energy—heat, light, electricity, X-rays and so on.

It occurred to a brilliant young Danish physicist, Niels Bohr, that this theory, with certain modifications, could be applied to the atom. The application turned out to be very successful. It not only accounted for the stability of the atom, but it also accounted for certain well-known experimental results which had never previously been explained. In making this application it was necessary, of course, entirely to abandon the old laws of radiation. It might be thought that this was merely an instance of the ordinary process of scientific advancement—merely the replacing of an old theory by a new and more comprehensive theory. But the curious and disconcerting fact is that the old theory of radiation cannot be completely abandoned. According to the old theory, radiant energy spreads out from its source in the form of waves. According to the new theory—the Quantum Theory—it spreads out like a flight of bullets. The two theories cannot be reconciled with one another, and yet there is very strong experimental evidence for both. Certain of the phenomena connected with the propagation of light have not yet been explained by the quantum theory, whereas the old wave-theory of radiation explains them perfectly well. On the other hand, there is a large class of phenomena, such as the liberation of electrons from metals under the impact of X-rays, that seems to be explainable only on the principles of the quantum theory. Amongst these phenomena we must include the processes that go on inside an atom.

The account we have so far given of the atom is more or less picturable. We have presented the electron as being something like a very small particle moving at a determinate speed round orbits of a determinate shape. This picturability is, however, largely illusory, as we find if we examine the picture in more detail. There is no need to make this examination, however, for every picturable element in the theory has now been given up.

The theory of the atom that we have outlined was first found to be seriously insufficient in 1925, and since that date an entirely different theory has been developed. This theory is, however, purely mathematical. The fundamental entities assumed by it are no longer picturable at all. The electron, for instance, on this theory is described not as a particle but as a system of waves. These waves are located within what is called a "configuration space." This configuration space is certainly not ordinary physical space, for the reason that each electron requires a three-dimensional configuration space to itself. Thus, two electrons require a space of six dimensions in which to exist; three electrons require a nine-dimensional space; and so on. It is evident, therefore, that the configuration space is not real space, and in this sense the wave system that represents an electron is a mere mathematical device and not a description of a physical reality. The justification of the theory is that it leads to calculated results which are confirmed by experiment. These results cannot be deduced from the older theory.

Since the resolution of an electron into waves seems to be merely a

mathematical device, it is distinctly baffling to find that there is experimental evidence for it. A number of experiments on the refraction and reflection of electrons show that they behave like waves. No satisfactory interpretation of these results has yet been given. They can hardly be taken as confirmatory of the mathematical theory, for that theory is not concerned with physical waves. And yet it is difficult to suppose that such results are entirely unconnected with the theory. All that we are justified in saying is that the mathematical analysis of an electron into waves does correspond to certain essential characteristics of the electron, but precisely how far that correspondence extends is a matter for future investigation. In the meantime it is safest to assume that all we know about the electron is its mathematical specification, and that we are not yet in a position to say what is the physical reality that obeys that specification.

The general theory of the atom as a structure of protons and electrons receives striking experimental confirmation from the phenomena of radio-activity. Radium, as is well known, shoots out two kinds of particles, called α-particles and β-particles. The nature of these particles is known. The β-particles are simple electrons. The α-particles are much more massive and much more complicated. An α-particle is, indeed, identical with the nucleus of a helium atom which, as we have already seen, is composed of four protons united with two electrons. Both α and β particles are shot out from the highly complicated nucleus of the radium atom. They testify to the actual disintegration of this atom. Each step in the disintegration of a radio-active substance (of which about forty are known) changes it into another element. Thus, radium passes through a whole series of transformations until it finally settles down as lead. The phenomenon of radio-activity is one proof, amongst many, that atoms are complex structures.

We have seen that the atomic theory of matter has changed out of all recognition since the days of Galileo. The scientific notion of matter has become steadily more and more abstract, until at present science can tell us nothing about it but its mathematical specification. The old familiar conception of an enduring substance has been replaced by a collection of mathematical symbols. We shall find that this process of abstraction is typical of modern physics.

§ 6

Besides the problem of the constitution of matter, the science of physics was early concerned with the nature of certain " influences," such as heat, light, sound, magnetism and electricity. Heat, as we have seen, was explained as the motion of little particles, and it was suspected that the other influences would turn out to be explicable as motions of some medium or other. In the case of sound the explanation was speedily forthcoming. Sound, it was shown, was due to waves set up in the air by a vibrating body. The waves travel through the air as alternate pulses of condensation and rarefaction. The bigger the swing of the air particles the louder the sound, and the more rapid the swing of the particles the higher the sound. This theory was worked out in detail, with the result

that the explanation of sound in terms of the movements of little particles was a complete success. But it was obvious that some new concept was required in order to explain light. Light is obviously not transmitted by the atmosphere.

If a vibrating electric bell be put in a glass jar and the jar exhausted of air, the sound of the bell becomes feebler and feebler until it becomes altogether inaudible. But we continue to *see* the bell vibrating as vigorously as ever. Further, light reaches us from the stars and we know that our atmosphere ceases to exist at a comparatively short distance above the surface of the earth. If light is due to motion in a medium, therefore, it must be a medium which extends as far as the farthest star.

An early theory, adopted by Newton, supposed that light was due to little corpuscles entering the eye after being shot out by the luminous body. In this way he explained the fact that light is propagated in straight lines. But he did not lay any great stress on this theory. He considered, also, the theory that light consists of waves in some subtle medium, or " ether," filling all space, although, if light is a wave motion, he thought it ought to bend round corners, as sound does. This difficulty could only be overcome by supposing that the light-waves are exceedingly minute. It could then be shown that the degree of bending should also be exceedingly small. The wave theory, in the hands of Huygens, showed itself a better instrument of research than the corpuscular theory, and its study was prosecuted with vigour.

The great problem presented by the wave theory of light was to determine the mechanical properties of the medium that conveys these waves. The fact that light is propagated with a definite velocity was established by the Danish astronomer, Römer, in 1676. He had observed that the satellites of Jupiter were sometimes irregular in their motions, and he had noticed that these irregularities depended on whether the earth was approaching Jupiter or receding from it. The brilliant idea occurred to him that, if light has a finite velocity of travel, it would take less time to meet the approaching earth than to overtake the receding earth. The velocity of light he deduced from his observations was astonishingly close to the value of 186,000 miles per second, which has since been determined by refined terrestrial experiments. The questions then arose : What are the properties of the medium that conveys light at this speed, and what is the nature of the waves ?

For some time the development of the theory of the ether was hindered by the assumption that light-waves, like sound-waves, are longitudinal—that is, consist in a to-and-fro motion in the direction of propagation. Certain experiments finally made it clear that this assumption cannot be correct, and that light-waves must be regarded as transverse—that is, as executed at right-angles to the direction of propagation, as occurs when a rope fixed at one end is shaken from the free end. When this fact was established the mathematicians were free to develop the theory of a medium that would support such vibrations. For years some of the best mathematicians in Europe devoted their attention to this problem. A great variety of ethers were worked out. They grew more and more complicated, and miracles of mathematical ingenuity were performed. But nobody succeeded in constructing a perfectly satisfactory ether. Nevertheless, the

nineteenth century cherished an almost passionate belief in the existence of the ether. In spite of all failures, the idea that the propagation of light was susceptible of a purely mechanical explanation became an article of faith. Men like Lord Kelvin stated that the ether was the most real thing in our experience and its existence the most indubitable of truths. Yet it continued to elude satisfactory mathematical specification.

The death-blow to the mechanical ether was given by the publication of Maxwell's electromagnetic theory of light, although nobody—not even Maxwell himself—realised that fact at the time. Maxwell's theory was based on the ideas of Faraday, who was the first to regard the space surrounding an electrified body as a seat of electric force. The older theory regarded electricity, vaguely, as a " fluid " confined to the surface of electrified bodies. The attraction or repulsion between electrified bodies was explained as an " action at a distance " phenomenon. The force between electrified bodies was supposed to be exerted instantaneously across the space separating them. Faraday approached the whole subject from an entirely different point of view. He regarded the electric charges as setting up a state of strain in the space surrounding them, and he regarded the forces of attraction or repulsion as being due to this state of strain. Maxwell adopted this theory and developed it mathematically. As a result of this development, he was led to declare that electromagnetic forces are propagated through space with the speed of light. Further, his calculations showed that these forces must travel in the form of waves very analogous to light-waves. Maxwell did not hesitate to deduce that light-waves actually are electromagnetic waves, that light is an electromagnetic phenomenon. Thus was announced the greatest physical discovery of the nineteenth century.

Experimental confirmation of Maxwell's theory was not forthcoming for twenty years. It was not until 1886 that Hertz, by a wonderful series of experiments, obtained full confirmation of the Maxwellian theory. He designed an apparatus for producing an oscillating electric charge and found that he could produce electric sparks in a circuit at the other end of the room, although the two pieces of apparatus were not physically connected in any way. He also measured the velocity of propagation of these effects, and found that they passed over the intervening space with the speed of light. Further, he showed that they behaved like waves, strictly analogous to light-waves. He reflected them from the walls of his room and refracted them through a large prism of hard pitch. Further experiments by other investigators showed still more resemblances, and Maxwell's electromagnetic theory of light was definitely established. The practical application of this discovery resulted in wireless telegraphy and telephony.

But the immediate scientific interest of Maxwell's theory lay in the light it threw upon the problem of the ether. All etheric vibrations, it was now understood, obeyed Maxwell's equations. The problem, therefore, was to give the ether the mechanical properties that would be compatible with Maxwell's equations. Ethers of an altogether incredible complexity arose in obedience to this demand. They were so complex that it is doubtful, even supposing one of them to have been successful, whether it would have been accepted. It would so obviously have been much more a *tour de force* than a revelation of the workings of nature. But, as

it happened, none of these ethers was successful. Scientific men began to realise that the explanation of all natural processes in mechanical terms was an impossible ideal. It became evident that henceforth certain concepts, other than mechanical concepts, would have to be ranked as fundamental for the science of physics. Electricity became a fundamental concept. No explanation of it in other terms seemed to be possible ; it had to be accepted as an ultimate fact of nature. Indeed, the inverse problem arose : Can mechanical processes be explained in terms of electricity ?

Although it became clear that a satisfactory description of the mechanism of the ether could not be given, the notion of an ether was not yet abandoned. The fact that light and electromagnetic processes in general are propagated through space with a finite velocity seemed to make the notion of a medium indispensable. And certain general questions could be asked about this medium, even although its constitution was unknown. The most important question was concerned with the relation between moving matter and the ether. Is the ether everywhere stationary, or does moving matter carry the ether along with it ? If the ether is everywhere stationary, then can the motion of the earth through it be detected ? A famous experiment, which has since been several times repeated, was undertaken by Michelson in 1881 to determine whether the earth moved through a stationary ether or whether it carried the ether in its neighbourhood along with it. The principle of the experiment is simple. Two equal arms are placed at right-angles and from the point of intersection a ray of light is passed along each arm and reflected back to the point of intersection. One arm points in the direction of the earth's motion in its orbit. The other arm is, of course, at right-angles to this direction. If the earth is travelling through the ether we should not expect the two rays of light to get back to the point of intersection at the same time. For if the earth and the ether are moving relatively to one another, the position would be analogous to that of two equally powerful swimmers, one of whom swims a certain distance up-stream and then down, while the other swims that same distance across stream and then back again. We know that, in this case, the second swimmer will make the faster time. Similarly, the light which travels along the arm at right-angles to the direction of the earth's motion through the ether should make the faster time. Nevertheless, the two rays of light arrived back at the point of intersection at the same moment. This experiment has been several times repeated. The apparatus has been turned at all angles, the experiment has been tried at various times of the year and at various heights above the earth's surface. Moreover, the apparatus is extremely sensitive, and can measure one-hundredth part of the effect to be expected if the ether is stationary. In every case the result is null.

Michelson concluded that the earth carries the ether in its neighbourhood along with it. But this conclusion entirely conflicts not only with other well-attested experiments, but also with certain astronomical observations of great weight and accuracy. In this dilemma it occurred to FitzGerald and also to Lorentz that the theory of a stationary ether could be preserved, in spite of Michelson's experiment, if we suppose that every body in its motion through the ether undergoes a certain contraction. If the arm of Michelson's apparatus which points in the direction of the

earth's motion is contracted in a certain ratio, thus making the light-path shorter, the null result of Michelson's experiment can be explained. Numerous experiments were made to test this new idea, but no direct evidence for it was forthcoming. Lorentz showed, however, that the postulated contraction fitted in with the electromagnetic equations.

This was the state of affairs when Einstein published his *Restricted Principle of Relativity* in 1905. He there laid it down as a fundamental principle that the velocity of light, whether measured from a system in motion or a system at rest, has the same value. This is obviously a very extraordinary principle. We are required to believe that a ray of light overtakes a moving system (whether the system is moving towards or away from the light) at the same rate at which it overtakes a system at rest. How can this be possible ? We begin to see that the principle is not a mere contradiction in terms if we reflect that a velocity is the ratio of two measurements, a measurement of length and a measurement of time. It is evident that if measurements made from two systems in relative motion reach the same value for the velocity of light, then something must have happened to the measuring instruments. This is, in essence, what Einstein asserts. He says that length and time-lapse are relative conceptions—they vary with the state of motion of the observer. The distance between two events (say, two flashes of light) is not the same for observers who are moving relatively to one another. Nor is the time-lapse between these events the same for all observers. A man carries, as it were, his own particular space and time about with him. The behaviour of his instruments, his measuring rods and clocks, varies with his motion. From the point of view of a stationary observer the moving observer's measuring rod is contracted and his clock is going slow. We cannot speak of the " stationary " standard of measurement, however, and say that it should be preferred. For our use of the word " stationary " is quite arbitrary. There is no experiment whatever which will show an observer whether he is *absolutely* at rest. All systems in uniform relative motion are on exactly the same footing. What we have called the moving observer may quite well suppose himself to be at rest, and then the erstwhile stationary observer becomes the moving observer. And his measuring rod is contracted and his clock is going slow, judged from the point of view of the other observer. In fact, the same judgment is made about his measuring instruments that he makes about the other observer's measuring instruments.

Each observer, as we have said, carries his own space and time about with him. All observers who share the same motion make the same space and time measurements. Observers whose motions differ make different space and time measurements. But these variations in measurement are not, of course, arbitrary. They are connected together by the fact that all observers reach the same value for the velocity of light—namely, 186,000 miles per second. From this fact we can find the precise formula according to which space and time measurements vary with motion. It is hardly necessary to say that, by referring to an " observer," we do not imply that there is anything " subjective " or " psychological " about this theory of relativity. Instead of " observer " we could substitute the phrase " automatic measuring apparatus " without affecting the validity of any of our conclusions.

We have said that observers in different states of motion do not find the same values for the distance separating two events, or for the time-lapse separating two events. Now, all events exist both in time and in space. No event exists at no time at all, and no event exists nowhere. The complete description of an event involves both the specification of the place where it occurred and also the time when it occurred. Between any two events, therefore, there is a spatio-temporal relation—that is, a relation comprising so much of distance and so much of time. If the time-lapse between two events happens to be zero, the events are said to be simultaneous. If the distance is zero, then, of course, they occur at the same place. Since the time measurements as well as the space measurements of an observer vary with his motion, it follows that two events which are simultaneous for one observer need not be simultaneous for another observer. Simultaneity is a relative concept. This follows, of course, from the fact that time itself is a relative concept. Yet, although different observers estimate quite differently both the space and the time separating two events, there is, nevertheless, a certain relation between these events on which they would all be agreed. If any given observer takes his space and time measurements referring to any particular pair of events and combines these measurements in a certain way, he will get a certain result. If another observer combines *his* measurements for the same pair of events in the same way, he will get the same result. The manner in which the measurements have to be combined is very simple. The time measurement has to be subtracted from the space measurement—after suitable units of time and space have been chosen. But the precise technique of the process is of no present importance. The important fact is that there exists a relation between any pair of events which is the same for all observers. This relation, it is obvious, refers to something more fundamental than either space or time taken separately. It refers to something that does not vary with the motion of the observer. What is this something?

The correct interpretation of the fact that there is an invariant relation between any two events was given by Minkowski. He showed that this relation (which is called the *interval*) was, in its mathematical expression, analogous to the mathematical expression for a *distance*. He suggested, therefore, that the interval is a distance of some kind. But, if the interval is to be regarded as a distance, it must be regarded as a distance in a four-dimensional continuum. Minkowski did not hesitate to take this step. The actual universe in which events exist is, he asserted, a four-dimensional universe. Our minds split up this universe into three dimensions of space and one dimension of time. Different observers, as we have seen, split up the universe differently. They take different cross-sections, as it were, of the four-dimensional reality. Therefore, they have different space and time measurements. Only those quantities which refer directly to the four-dimensional reality itself are the same for all observers. Of such quantities the interval is one.

The fact that the interval could be regarded as a distance in a four-dimensional continuum immediately illuminated the whole theory of relativity. For it showed that the geometry that must be applied to the universe was not, as had always been supposed, Euclidean geometry. The reader is probably familiar with the fact that during the last hundred years

a number of non-Euclidean geometries have been invented. For something like two thousand years it had been considered that the axioms on which Euclidean geometry are based are necessities of thought. It is now known that these axioms are, logically speaking, arbitrary. An entirely different set of axioms can be chosen and an entirely logical and self-consistent geometry be built up on them. All that is necessary is that the chosen axioms shall be consistent with one another. All geometries, Euclidean and non-Euclidean, are equally logical and self-consistent. There is no *a priori* reason for preferring any one of them to any other. It becomes a matter of experiment, therefore, to decide which of them can most conveniently be applied to the description of natural phenomena. The geometry we want is the geometry which will best describe the observed behaviour of our measuring appliances. Our measuring appliances may consist of rigid rods and mechanical clocks, or we may find it more convenient, in some cases, to use rays of light and vibrating atoms. The question is : What geometry best expresses their behaviour ?

We have said that Minkowski interpreted the *interval* as a distance in a four-dimensional continuum. Now Riemann, the great German geometer, had shown that the essential difference between all the different geometries, Euclidean and non-Euclidean, could be traced to the fact that each geometry gave a different mathematical formula for the distance between two points. The formula for the interval, if interpreted as a distance, made it clear that the geometry of the four-dimensional continuum was not Euclidean. Yet it was, in certain respects, very like Euclid's geometry, and for that reason was called " semi-Euclidean." But the differences are of great importance. It can be deduced, for instance, that in a continuum subject to this geometry there is a maximum velocity. In a Euclidean continuum, as we know, it is theoretically possible for an infinite velocity to exist. Whatever speed we suppose a particle to be travelling at, we can always imagine it travelling at a greater speed. But in a continuum governed by semi-Euclidean geometry this is not the case. An infinite velocity is not possible in such a continuum. The *ultimate* velocity is a certain finite velocity. It is, therefore, strongly confirmatory of Minkowski's conception that the velocity of light is found, in relativity theory, to play the part of an ultimate velocity. The velocity of a material body cannot, according to the theory of relativity, ever exceed the velocity of light. For it can be shown that the mass of a body increases with its velocity, and increases in such a way that at the velocity of light it becomes infinite. This increase in mass is not measurable except at speeds comparable with the speed of light. Some of the particles shot out by radium move at speeds sufficiently great to enable the increase of mass to be measured. At half the velocity of light the mass of an electron (or any other body) is increased by one-seventh. At nine-tenths the velocity of light the mass is nearly two and a half times greater, while at ninety-nine-hundredths of the velocity of light the mass has seven times its value at rest. At higher speeds the mass increases very rapidly until, as we have said, it becomes infinite at the velocity of light. This can only mean that the speed of light is a natural limit for moving matter. In a continuum governed by Minkowski's geometry it behaves, in fact, as if it were an infinite velocity.

There is another respect in which the velocity of light behaves as if it

were infinite. We are accustomed to suppose that velocities can be added to one another according to the ordinary arithmetical law of addition. Thus, if a particle passed an observer with a speed three-quarters that of light, and another particle passes the observer in the opposite direction at the same speed, it would appear that the relative speed of the two particles must be one and a half times the velocity of light. Since all motion is relative, either of these particles can be considered as at rest, and then the other must be reckoned as moving half as fast again as light, thus violating the relativity principle that the velocity of light is an ultimate velocity. The fact is, however, that velocities do not combine according to the arithmetical law of addition. If a train passes an observer on the platform at sixty miles an hour and a man walks down the corridor with a velocity, relative to the train, of four miles per hour, his velocity, relative to the man on the platform, is not sixty-four miles per hour. It is less than this sum. The relativity formula for the addition of velocities shows that however many velocities relative to the same observer be added together their sum can never exceed the velocity of light. This strange result is again due to the curious geometry of the four-dimensional continuum. None of these results are perceptible, of course, except at speeds altogether outside our ordinary experience. Otherwise, we would not have had to wait so long for the theory of relativity.

Another very important result of relativity theory is the light it throws on the relation between matter and energy. There are, as is well known, various kinds of energy. Thus, there is the energy possessed by moving matter, as in the case of a rifle bullet, a stream, or a wind. There is energy of strain, as in a bended bow. There is heat energy, light energy, electrical energy. All these forms of energy are capable of doing work, and they can all be transformed into one another. Moreover, the transformation always takes place in a fixed proportion. The same amount of heat energy, for example, will always produce the same amount of energy of motion, or of electrical energy, or what not. Further, no energy is lost or created in the process of transformation. This fact is expressed by the principle of the Conservation of Energy. Energy is akin to matter in the fact that it cannot be either created or destroyed. But relativity theory has shown that the kinship is a much closer one than is expressed by saying that both matter and energy are conserved.

We have already said that a moving body has a greater mass than is possessed by the same body at rest. Now the moving body, in virtue of its motion, has acquired a certain amount of energy—kinetic energy, as it is called. According to Einstein this energy has mass. Indeed, the extra mass of the moving body is due to the mass of its kinetic energy. And what is true of kinetic energy is true of any other form of energy. All forms of energy have mass. Since mass is the cardinal property of matter, this fact suggests that energy and matter are convertible terms. We may regard the mass of a body at rest as the mass of the congealed energy, as it were, that constitutes the body. If matter could be changed into energy we should have incomparably the greatest source of energy possible. A thimbleful of mud, for example, if changed into energy, would be sufficient to drive a large ship across the Atlantic.

§ 7

A striking peculiarity of the Restricted Principle of Relativity, as we have described it, consists in the rôle played by geometry. Various phenomena, instead of being referred to special laws of nature, are shown to be consequences of the fact that the four-dimensional continuum is governed by a certain semi-Euclidean geometry. What, then, is the relation between geometry and laws of nature? A simple illustration showing how this question might arise has been given by Poincaré. Let us consider the triangle formed by three stars. According to Euclid's geometry the three interior angles of this triangle should together equal two right-angles. Let us suppose that actual measurements of these angles show that they are not together equal to two right-angles. Should we conclude that Euclid's geometry is not the geometry of space? Not necessarily. For in making these measurements we have assumed a law of nature—namely, that light is propagated in straight lines. It might be possible for us to account for our measurements by giving up this law while still retaining Euclid's geometry. This example is sufficient to show that what we call a law of nature may be at least partially dependent on the geometrical assumptions we begin with.[1]

The most celebrated of all scientific laws is Newton's law of gravitation. Newton imagined a force of attraction exerted between every particle of matter in the universe and every other particle, and he gave the law according to which this force varies with the masses and distances concerned. In particular, he gave an extremely satisfactory description of the motions of the planets by supposing the sun and the planets to be exerting this force of attraction on one another. It is interesting to see how far this conception of gravitation was necessitated by Newton's more fundamental assumptions. The only geometry known in Newton's time was Euclidean geometry, and Newton doubtless regarded Euclid's presuppositions as necessities of thought. When, therefore, Newton said that the natural motion of a body acted on by no forces is motion in a straight line, he was thinking of a Euclidean straight line. But the assumption that the unhampered motion of a body is motion in a Euclidean straight line makes the invention of a force of gravitation inevitable. The "natural" motion of a body, one would suppose, is the motion of a body which is not subject to impacts of any kind. But the planets are not subject to impacts. An earlier theory had supposed that angels carry the planets round the sun in just the way they are observed to go round. This may be called an "impact" theory. But Newton, needless to say, did not believe in any impact theory. Why, then, did not the planets travel in straight lines? Newton concluded that there was a force pulling them out of the straight line path. He called this force "gravitation." It is to be observed that this force was invented purely because the planets did not behave as Newton thought unhampered bodies should behave—that is, they did not travel in Euclidean straight lines. Thus, we see that the force of gravitation was the inevitable outcome of Newton's assumption that the geometry of space must be Euclidean. If we do not make that assumption, can we get

[1] For further discussion of this subject see the Article on *The Nature of Mathematics*, p. 188.

rid of the force of gravitation? In other words, can we explain the observed motions of the planets as being their natural motions in a non-Euclidean space?

This was the problem that Einstein solved in his *Generalised Principle of Relativity*, published ten years after the *Restricted Principle*. The later theory may justly be regarded as a generalisation of the earlier theory, for while the earlier theory deals only with observers who are moving in straight lines with constant velocities, the later theory places no restrictions upon the motions of the observers. The aspect of the later theory that interests us here, however, is its attitude towards the whole problem of gravitation. Einstein showed that the force of gravitation is a superfluous concept, and that all the phenomena that had been accounted for by that force could be equally well explained in terms of a certain non-Euclidean geometry. In order to carry through this idea, Einstein had to adopt Minkowski's conception of a four-dimensional continuum. But he had to attribute to this continuum an altogether more complicated geometry than that proposed by Minkowski. We have already said that Minkowski's geometry is, in many respects, very like Euclid's. One very important point of resemblance consists in the fact that the natural motion of a body in a continuum governed by Minkowski's geometry is motion in a Euclidean straight line. Minkowski's geometry affords no assistance in the enterprise of abolishing the force of gravitation. Nevertheless, Minkowski's conception of the world as four-dimensional was an essential contribution to the general theory of relativity. If Einstein was to discover a geometry which would do the work of the force of gravitation, this geometry must be applied not to space only but to the four-dimensional space-time.

Einstein solved this problem. He showed that if the space-time continuum possesses certain metrical properties, then the motions of the planets are in the " straight lines," or geodesics, proper to this kind of continuum. In speaking of the motions of the planets we do not refer merely to their paths in space, their elliptical paths, but to their paths in the four-dimensional continuum, which are a kind of spirals. In the neighbourhood of a double star a planet's spatial path would not be an ellipse, and its four-dimensional path would not be a spiral. It would, however, describe the " straight line " appropriate to that part of the continuum. Thus, we see that the continuum must have different metrical characteristics in different parts of it, and that these differences are connected with the distribution of matter in the different regions. Thus, there is no one definite geometry that can be applied to the whole of space-time. The geometry required is a very general, flexible geometry, which admits of a considerable range of local variations. This general geometry, which Einstein has applied with such success, is called " Riemannian " geometry, from Riemann, who first discovered it.

The metrical properties, the geometry, of any portion of space-time, depend upon the distribution of matter in that region. A planet moves round the sun in an ellipse, not because there is a force of gravitation pulling at it, but because that is the natural motion of an unhampered body in the sort of space-time that exists in the neighbourhood of the sun. For the same reason a ray of light that passes near the sun describes a curved

path. This fact, which was predicted by Einstein's theory, has been confirmed by measurements made by various eclipse expeditions. Stars near the sun (that is, in very much the same line of sight) cannot normally be seen, as their light is overpowered by the sun's light. But during a solar eclipse they become visible. If their light, in passing near the sun, is bent, it follows that the stars should appear displaced compared with the positions they occupy in the sky when the sun is not there. Einstein's theory enables the amount of the displacement to be calculated, and these calculations have been fully confirmed by observation. Time measurements, as well as space measurements, are influenced by the presence of the sun. A vibrating atom may be regarded as a natural clock, and it can be shown that atoms on the sun should vibrate more slowly than similar atoms on the earth. Thus, the light they emit, which depends on the rate of vibration, should be of longer wave-length than the light emitted by similar atoms on earth. This result has been confirmed by spectroscopic observation. A third result of the theory, which has also been confirmed by observation, deals with the motion of the planet Mercury. According to Newton's law of gravitation, an isolated planet should describe an ellipse round the sun. But no planet in the solar system describes a strict ellipse, since any planet's motion is influenced by the gravitational attraction of all the other planets. This influence is most apparent in the case of Mercury, for its orbit is the most markedly elliptical of any of the planetary orbits. When the calculations were made, however, it was found that there was a discrepancy between the theoretical result and the observed motion of Mercury. Many attempts were made to explain this discrepancy, but none of them was successful. Einstein's theory gives a complete explanation of the whole thing. These three observational results, together with the inner coherence and harmony of the theory, have caused it to be generally accepted. It may be taken as proved, therefore, that the universe exists in a four-dimensional continuum governed by Riemannian geometry.

Gravitation and all the laws of mechanics can be deduced from the fact that space-time is subject to Riemannian geometry. These laws are not special and isolated laws of nature. They are inevitable consequences of the geometrical peculiarities of space-time. Thus, the world has been immensely simplified. Instead of laboriously discovering one special law after another, we deduce them all from one set of premises. But the unification of nature is not yet complete. One great set of laws—namely, the electromagnetic laws which govern the propagation of radiant energy through empty space—have not yet been brought into the scheme. Also, relativity theory throws no light on the fact that matter is atomic in constitution, nor on any of the phenomena that are dealt with by the quantum theory. But certain steps towards a complete unification have been taken. Attempts have been made, for example, to bring electromagnetism into the geometrical scheme. The procedure, in each case, consists in inventing a geometry which, while allowing the laws of gravitation and mechanics to be deduced, shall also be sufficiently general to include the laws of electromagnetism. Electromagnetism, in fact, is to be made a necessary consequence of the geometrical peculiarities of the space-time continuum. It could be shown that the original Riemannian geometry used by

Einstein could not do this. All its geometrical peculiarities were exhausted, as it were, in accounting for gravitation and mechanics. A still more complicated geometry is necessary if electromagnetism is to be included.

One of the most interesting of these attempts is that of Eddington, and it is worth mentioning here because of the general nature of its conclusions. Eddington begins by attributing to the four-dimensional continuum almost the minimum amount of structure conceivable. Compared with the firm outlines of Euclidean geometry, the geometry assumed by Eddington is almost completely amorphous. Nevertheless, from this bare material, and making the minimum number of assumptions, he derives the laws of gravitation, mechanics and electromagnetism as being necessary consequences of this primitive structure. A piece of matter, on this theory, is a place where the continuum is curved in a certain way. It is not that the piece of matter produces the curvature; the curvature is the piece of matter. The " objective reality " is a continuum possessing certain kinds of curvature. As a result of the mind's selective action on this raw material the universe of physics, matter and its laws arise. Space and time are not fundamental on this theory. The " interval " with which Eddington starts is not, to begin with, a spatio-temporal relation. The mind splits up the interval into space and time components, but this is done in obedience to imperious psychological laws. The division into space and time is not imposed on us by nature; we impose it on nature. The whole universe of matter is, on this theory, a much more subjective affair than we had hitherto supposed. It arises as a result of the mind's selective action on certain raw material. A different mind from ours would fashion a different universe out of this same raw material. There are certain mathematical consequences of the existence of this raw material to which our mind pays no attention. Such consequences do not form features in the universe of our perception. Out of all the different aspects or combinations of the raw material the mind pays attention to some only.

What can we say about the nature of this raw material? Eddington maintains that, by the methods of science, we can learn nothing about the raw material except its structure. The primary elements of the raw material with which he starts are undefinable. He calls them " point-events," but all we know about a point-event is that four numbers are required to specify it. We can illustrate what this means by an analogy. To specify a house in New York, for instance, we require to know the number of the street and the number of the house in that street. To specify a musical note we require to know its pitch, its loudness and its *timbre*. Both pitch and loudness can be represented by numbers, and *timbre*, which is due to wave-shape, could conceivably be given numerical expression. If these particulars are given about a musical note they suffice to distinguish it from all other musical notes. Point-events, whatever they may be, require four particulars to distinguish them unambiguously, and each of these particulars can be represented by a number. That is all we require to know about point-events for the purposes of science. To use one of Eddington's illustrations, it is as if all we knew about the Big Four at Versailles was that they numbered four. Between pairs of point-events is a relation called the " interval," and this relation can be given mathematical expression. And from this the existence of matter and its laws

can be deduced. Thus, the world of physical science is due merely to the *structure* of the four-dimensional continuum of point-events. Of the *nature* of the raw material science tells us nothing.

This attempt of Eddington's to geometrise the world has been mentioned chiefly because it affords a clear instance of his contention that science tells us nothing about the nature of reality, but only about its structure. This is a point of view which, as we shall see, is becoming very prominent in modern scientific speculation.

The fact that the four-dimensional continuum is governed by a non-Euclidean geometry raises the question as to whether space is finite. As long as space was supposed to be governed by Euclidean geometry such a question had no meaning. For to ask whether space was finite was equivalent to asking whether it had boundaries. Obviously, space cannot have boundaries, for what can we conceive to lie beyond the boundaries? But it is possible for a non-Euclidean space to have no boundaries and yet to be finite. A simple example is provided by the surface of a sphere. Regarded as a two-dimensional object, the surface of a sphere is not Euclidean. On the surface of a sphere, for instance, the three interior angles of a triangle are not together equal to two right-angles. Creatures confined to the surface of a sphere and having no knowledge of a third dimension would develop a non-Euclidean geometry. And their space, which is the surface of the sphere, has no boundaries. These creatures could crawl for ever over the surface of their sphere in any direction without ever meeting any barrier to their further progress. They would come back to their starting points, but they would never reach a stop. Nevertheless, the total area of their space would be finite. Similar conclusions hold good when we come to consider a non-Euclidean three-dimensional space. It is possible for the total volume of such a space to be finite, although there are nowhere any barriers. It is, therefore, a perfectly sensible question to ask whether the space in which we live is finite but unbounded.

The notion that space is infinite has always been attended by certain difficulties. Consider, for instance, the distribution of the stars. Are we to suppose that the stars are scattered more or less uniformly throughout infinite space? Or are we to suppose that they all exist within a limited volume of space, and that empty space spreads out to infinity in all directions about them? Each of these alternatives has its own difficulties. If the stars are scattered uniformly throughout space, it can be shown that the night sky should be very much more luminous than it is. If the stars form an island in infinite space, then, under the influence of their mutual attractions, some of them should attain very great velocities. Such velocities have never been observed. Such difficulties are among the reasons that led Einstein to formulate the theory that the universe is finite but unbounded.

The theory that the universe is finite is now generally accepted, although there is some disagreement as to its form. But the theory which seems to be, on the whole, most probable assumes that time is curved as well as space. This universe has a tendency to expand. Particles initially close together tend to scatter. This is, to some extent, borne out observationally by the fact that the spiral nebulæ, which are considered to be

"island universes" quite outside our main galactic system, are most of them receding from us with considerable velocities. These velocities are deduced from spectroscopic observations. The light from the spiral nebulæ is displaced towards the red end of the spectrum, and measurements of the displacements enable us to calculate the velocities of recession. But this effect is complicated by the fact that the time dimension is curved. This will have the effect of slowing down all distant processes. The shifting of the light towards the red end of the spectrum may be partly due to the slowing down of time at such vast distances, for the atoms of the nebulæ, by vibrating more slowly, would send out a redder light than similar atoms on earth. At a certain distance, at what is called the "horizon," time would slow down completely and all natural processes would stop. This effect is illusory in the sense that if we transported ourselves and our instruments to the horizon we would find everything going on normally, and the horizon would now appear to be at the place we had left. This theory is due to the Dutch mathematician de Sitter. On Einstein's original form of the theory particles did not tend to scatter, and there was no slowing down of time. A form intermediate between these theories has been proposed, and the whole question is still in process of investigation. It appears, however, that the hypothesis of a finite, re-entrant space must be accepted. We may put it crudely by saying that space bends round on itself. This is not true, however, of time. There is no reason to suppose that time is "closed," and so there is no reason to believe in the nightmare of "eternal recurrence."

Time, in science, extends indefinitely into the past and indefinitely into the future. The scientific concept of time is as a bare succession. Future and past are distinguished merely by a difference of sign; there is no essential difference between them. The equations which enable us to determine the future, as when we predict eclipses, can equally well be made to work backwards. It is doubtful whether this simple conception of time will always prove adequate for the purposes of science. It may be that something more akin to our intuition of a creative advance in nature will have to be adopted. However that may be, the present scientific conception of time regards the passage from the present to the future, or from the present to the past, as being no more than the passage to the right, or to the left, along a straight line. There is, nevertheless, one respect in which science recognises a difference between the future and the past when the material universe as a whole is considered. It can be definitely stated that the available energy of the universe is steadily becoming less.

We have already said that energy is conserved. The total amount of energy in the universe remains constant. In view of what we now know of the relation between matter and energy, this statement must be amended. We must now say that matter and energy, taken together, are conserved. This amendment does not affect the statement, however, that the available energy of the universe is steadily becoming less. Energy passes from higher to lower levels. Heat passes from a hot body to a colder one. This passage of energy can be used to do useful work. But no work can be obtained from a number of bodies at the same temperature. We may consider an isolated system, from which no energy is lost, and

which is composed of bodies initially at different temperatures. In course of time all these bodies will reach the same temperature. They have not, as a whole, lost any energy, but their energy is now unavailable. In all energy transformations, whatever the kind of energy concerned may be, there is a loss of availability. The movement of the whole universe towards a uniform temperature is a process which, so far as we know, cannot be reversed. The general idea can be put rather differently if we say that the degree of organisation of the energy of the universe steadily grows less. In a swinging pendulum, for instance, the organised energy of motion is gradually transformed into a less organised form. The pendulum gradually comes to rest through the friction of its supports and through the resistance offered by the air. The energy of motion of the pendulum has been used up in increasing the chaotic motion of the air molecules and in heating the supports, that is, in increasing the chaotic molecular motions of the supports. The energy, in its organised state, has disappeared. The resulting disorganised energy, although quantitatively equal to the original energy, will never spontaneously assume the organised form. It has become less available. This change, from a more highly organised to a less highly organised form, is continually taking place in natural processes. And it appears that this process must inevitably go on until the disorganisation of the energy of the universe reaches a maximum. This final state, the end of the universe, must occur within a finite time.

If, using this same argument about the disorganisation of energy, we turn our attention to the past history of the universe, we see that the universe must have been more highly organised the farther back we go. This process, also, has its maximum. A finite time ago the universe must have been in a maximum state of organisation. This state could not have been evolved from any less organised state. It appears that the universe must have had a definite beginning in time. The accepted laws of physical science do not enable us to trace the universe through an indefinite past. Further, the chances against this highly organised state having come about at random can be shown to be practically infinite. The universe, as we know it, must have originated a finite time ago, and it could not have originated by chance. The origin of the universe, it would appear, is not a problem that can be brought within the scheme to which science confines itself. Whether this indicates that the universe had a transcendental origin, or whether it indicates that science, as a scheme, is not yet completely coherent, is at present a matter of opinion.

§ 8

The principle we have just described, the principle that the available energy of the universe grows steadily less, is known as the second law of thermodynamics. It is essentially a statistical law. It is one of those laws that do not deal with single elements, but with large assemblies of them. It is now realised that many of the older laws of physics are really only statistical laws and are derived from our experience of matter in bulk. When we come to study the actual elements of the physical world, such as protons and electrons, we find that the laws governing their individual

behaviour are quite different from the laws governing their behaviour as assemblies. The most striking difference arises when we come to investigate the relation of cause and effect as applied to the elements of the physical world.

Physical science has long been supposed to present nature as a completely determined scheme. It has been a cardinal assumption of science that a given state of affairs determines uniquely the next state of affairs. If we are given all the relevant data about the present state of the solar system, for instance, we can predict any future state of the system. If we cannot do so it is merely because our observations are imperfect or that we do not know accurately the laws involved. In itself the system is completely determinate. In all the phenomena with which science was concerned this principle seemed to be verified. Predictions of eclipses, as everybody knows, come off. This principle was, by some people, generalised to include the phenomena of life and mind. Free-will was regarded as an illusion. Laplace boldly expressed the view implied in the beliefs of many scientific men when he stated that from the original distribution of the atoms in the primitive nebula a sufficiently great mathematical intelligence could predict the whole future history of the world.

The abandonment of this assumption is one of the most striking characteristics of the present scientific outlook. Strict determinism cannot be traced in the behaviour of the ultimate elements of the physical world. In these elements we include the " atoms of energy " or quanta, as well as electrons. The behaviour of a quantum of light as, for example, in which of two directions it will go, is found to be a matter of probabilities. In one experiment the quantum will choose one path. In a repetition of the experiment repeated under identical conditions it will choose the other path. If the experiment be repeated a great number of times, the percentage of the times the quantum chooses one path or the other can be reckoned up. It is then possible to enunciate a law specifying the probability that on any given occasion the quantum will take one path or the other. The same holds good of the motion of an electron. The chances that it will reach a position B from a position A can be given. But its future conduct is not uniquely determined by its present state. When a sufficiently large number of electrons are taken, as happens in any piece of matter with which science deals, their individual idiosyncrasies cancel out, as it were, and the resultant behaviour of the assemblage is determinate.

It might be thought that a closer observation of the electron would determine the conditions that cause it to jump one way rather than another. But an electron cannot be examined without interfering with it. An electron has a detectable existence only while it is interacting with the rest of the universe. An electron which is playing no part in the production of phenomena is in an unobservable state. But an electron cannot be detected (it could not, for instance, even be seen in an ideal microscope) without at least one quantum of energy being involved in the process. And this one quantum is sufficient to disturb the motion of the electron in an unpredictable way. Heisenberg's Principle of Indeterminacy states that an electron may have position or it may have velocity, but it cannot in any exact sense have both. The more exact the determination of the position of an electron the vaguer becomes its velocity, and the more

exact the velocity the vaguer the position. How are we to interpret this principle ? Are we to say that it is merely an expression of the fact that our methods of measurement are defective—perhaps inherently defective—but that, nevertheless, an electron's behaviour is strictly determined ? Or are we to interpret the principle as an indication that the law of strict causality does not apply to the fundamental operations of nature ? At the present time scientific men are of two minds about this matter. Those who maintain that nature is finally undetermined ask what is the use of postulating a law of causation that can never be discovered ? If our measurements necessarily fail to reveal strict determinism, why assume that determinism nevertheless exists ? This question is very pertinent in view of the tendency of modern science to seek for no explanations except in terms of observable entities. By " observable " one must understand " detectable by physical processes." Newton, for example, explained the centrifugal force developed by a rotating body in terms of the body's relation to absolute space. According to Einstein, absolute space cannot be detected by any physical processes. He therefore regards it as an illegitimate entity in a scientific explanation. In Bohr's early theory of the atom we were asked to imagine electrons revolving round a central nucleus and occasionally executing jumps from one orbit to another. It was only while the electron was jumping that it interacted with the rest of the world. In the meantime, while it was steadily revolving in one orbit, it was immune from all detection. Bohr's picture of the atom therefore contained an unobservable element. Heisenberg replaced this scheme by one where none but observable factors was involved.

The banishment of determinism from the ultimate processes of nature is quite in keeping with this modern tendency. But is it possible to conceive of undetermined phenomena ? It would seem that the answer to this question depends on whether we think we have an intuition of free-will or not. If we can regard free-will as an unanalysable category of thought, then we may suppose something analogous to free-will to lie at the basis of material phenomena. Free-will and determinism then become theoretically two equally valid alternatives, and which one we adopt is to be decided purely by the evidence.

§ 9

We see that physical science has become a radically new thing since the days of Galileo. Science to begin with tried to account for phenomena in terms of notions made familiar to us by our ordinary experience, notions such as fluids, particles, pushing and pulling and so on. Up to a certain point this effort was successful. There are many phenomena which can still be accounted for in these terms, provided the analysis is not pushed beyond a certain limit. The first really big failure of this method of thought was the attempt to account for light as consisting in the vibrations of an elastic solid fitting all space. But although the elastic solid theory failed, the ideal of a mechanical explanation of light was not given up. The ether became more and more unlike anything in common experience, but the fundamental concepts used in constructing it were still mechanical. But the fact that no satisfactory mechanical ether could be

designed led some to wonder whether the body of concepts that science had in stock, as it were, were really adequate. This moment was a turning-point in the history of science. Science no longer insisted that the description of the material universe *must* proceed in certain terms. Since then science has introduced a number of new concepts. But they have this in common with the old ones, that they are all capable of mathematical definition. Whatever words science may use for its concepts, light-quantum, distance, mass, four-dimensional continuum, electron, or whatever they may be, we find in each case that each of these words stands for a body of mathematical relations. Many of them differ from the old concepts in the fact that they are not picturable. But the " picturability " of the old concepts was really a quite irrelevant fact about them. The old terms, just as much as the new, stood for certain mathematical relations, and only so far as they did so were they of any importance to science. The fact that the Victorian " atom " conjured up the notion of a tiny grain of sand doubtless brought comfort to the mind, but it was only the mathematical specification of the atom that played any part in atomic theory. It is characteristic of the modern scientific man that he is sufficiently self-conscious to realise that he is *only* talking about certain mathematical relations when he talks about the entities out of which he intends to construct the universe. Provided that he has reason to suppose that his mathematical specification of an electron or what not is correct, he is not worried by the fact that the entity that fulfils that specification is not picturable.

This realisation of the nature of science makes it clear that the material universe is a much more subjective thing than Galileo, for instance, supposed. It is difficult now to make the hard-and-fast distinction between primary and secondary qualities that Galileo made. If our perception of the colour red is merely our interpretation of certain electromagnetic waves, our perception of a tennis-ball is, it appears on the wave theory of matter, merely our interpretation of waves that are still more mysterious. Or if we turn to relativity theory, we find that what we perceive as a tennis-ball is " really " a region of a four-dimensional continuum possessing a certain kind of curvature. Science does not tell us anything about the substance of the elements out of which we have built up the preceptual world. It tells us merely the mathematical specifications of those elements.[1]

ASTRONOMY

By

R. A. SAMPSON

SYNOPSIS

Astronomy occupies at the present time a position of remarkable interest — Each of the physical sciences is now emerging into view of the others — What Astronomy has learnt illuminates physics and chemistry and in turn is illuminated by them — At the same time, in its own region, it has succeeded, far beyond what the most sanguine could have dreamed, in learning with certainty the nature, the position, the motions, even the constitution of the heavenly bodies — Our limit of knowledge, and even of ambition and ideas, a century ago, was the solar system; this is now passed briefly by, as having little that is significant to tell — The stars are the real problem — We have successively found methods of reaching securely further and further out, and of determining the nature, the order and the structure of the stars — Not of individual stars alone, but their general history, grouping and genesis — Thence we are led on to wider theories of the universe as a whole — This Article attempts to convey a picture of this extraordinary field.

pages have been written from the point of view of gradual, inevitable growth. Astronomy is connected in common parlance with a set of startling discoveries. To the astronomer himself it appears much more a gradual unfolding. It will be appreciated that this attitude makes astronomers good and cautious judges of any new announcement.

THE SOLAR SYSTEM

When they are viewed directly, and as they presented themselves to the earliest observers, the Sun, Moon and planets show none of their true relationships. The Earth seems the most important body. The Moon appears as a body that may be compared with the Sun. The planets divide into two groups and have no likeness to the Earth. If we rearrange the same facts, but take the Sun as centre, the real system becomes evident. The Sun is indeed much the greatest body; it is a hundred times the diameter of the Earth, which means a million times its volume. It has 330,000 times its mass. Physically the Earth has no title to the chief place. The planets *Mercury*, *Venus*, the Earth, *Mars*, *Jupiter*, *Saturn* are spaced out, in their distances from the Sun, with a certain regularity which is emphasised by adding the ring of minor planets between *Mars* and *Jupiter*, and *Uranus* and *Neptune* beyond *Saturn*. They move round the Sun in the same direction, in nearly the same plane.[1] The system is evident, though no formula covers the succession of distances.

So far as we can examine them the planets present a wide range of surface conditions. This is to be expected, because their distances from the Sun would imply a great difference of temperature. If the Sun governs the temperature and there is no contribution of internal heat—a state of affairs that corresponds with conditions on the Earth—the mean temperatures would range from 200° C. on *Mercury* to —200° C. on *Neptune*. *Venus* would be about 70° C. and *Mars* —40° C. But such mean temperatures may allow a wide range, unless there is an atmosphere to trap incoming and outgoing heat. By inspection with the telescope, *Venus* appears cloudy, with little detail to fix on. *Jupiter* is certainly cloudy, though definite features, like what is called the " Great Red Spot," persist semi-permanently. It has a low mean density which suggests that the cloud layer may be deep. *Saturn* is much the same. Most of the others offer no definite information. *Mars* alone can be examined in some detail. It is small and its atmosphere is light. By putting together what different observers agree upon, it has been mapped pretty precisely, so that we can speak even of the changes that occur upon it. These changes follow its year. Round its poles, there are what seem to be ice caps, which increase and diminish. Concurrently, changes take place in its topographical features. What these are we can only guess. Large parts of it show an orange tinge, giving the planet its ruddy colour. One might suppose they are deserts. If we describe the rest as " vegetation " or " seas " we must do so with reserve, admitting considerable ignorance and keeping the temperature in mind. But in any case, this is far more than we know of the other planets. How difficult it is to learn,

[1] The new planet *Pluto* cannot be included.

will be appreciated by saying that under the most favourable circumstances mapping *Mars* is like reading the inscription on a coin at a distance of several hundreds of yards.

Three additions have been made to the major planets known from the beginning. *Uranus* was discovered by Herschel in 1781, because he saw it was not a mere point, like a star. *Neptune* was found by Adams and Leverrier independently, assigning its existence and place mathematically so as to explain why *Uranus* did not follow Newton's theory of gravitation. The planet was thereupon discovered within about a degree of the stated place, in 1846. Some fuller details of this are given in the next section as also of the latest addition to the solar system, the planet *Pluto*.

A word may be added about the Minor Planets. Of the thousand or more that are now known, most are an undistinguished horde whose orbits lie between those of *Mars* and *Jupiter*. But one stands out notably —*Eros*—because its mean distance from the Sun is actually less than that of *Mars*, while its least distance periodically brings it much closer. It is at these times our nearest neighbour. Thus its distance in 1901 was 30 million miles; in 1931, 16.2 million only. Such occasions are far the most favourable that are offered for direct measurement of the scale of our system. The accepted distance of the Sun, 93 million miles, was so derived from the approach in 1901.

Coming to the satellites, except the Moon, no other was suspected until Galileo in 1610, a few days after he turned his telescope on the sky, detected, " with incredible jollity of mind," the four great satellites of *Jupiter*. He saw also later the ring of *Saturn*, but this was first recognised for what it was by Huygens in 1672. Huygens found too the greatest of *Saturn's* satellites. The ring itself is now known to be a host of small satellites, each moving according to an orbit of its own in *Saturn's* equatorial plane. J. D. Cassini added four more satellites to *Saturn*, W. Herschel two others, and two to *Uranus*. Two further satellites of *Uranus* were found by Lassell, who also discovered a satellite of *Neptune*. An eighth satellite of *Saturn* was found by G. P. Bond in 1848. Asaph Hall discovered two for *Mars* in 1877, the inner of which has the remarkable feature of revolving round the planet three times in the latter's day. More recent discoveries have not been wanting. Barnard added a fifth small inner satellite to *Jupiter* in 1892, Perrine two others outside the old system, Melotte an eighth and Nicholson (1914) a ninth, while W. H. Pickering added a ninth to the system of *Saturn*. While the earlier discoveries show on the whole a high degree of regularity in the systems, the outer members rather shake one's belief in its significance. The ninth satellite of *Saturn* goes backwards compared to the others. The eighth and ninth satellites of *Jupiter* do the same. The last two are also at enormous distances from the planet and subject to such enormous perturbations that no orbit fits them, and their places can only be computed step by step as needed.

The planets with their satellites, in their comparatively regular sequence, are not the sole constituents of the solar system. Much stranger members are the comets. We know them to be permanently attached to our system, because they share in the solar motion through space.

Several are detected every year, which usually make one revolution round the Sun and depart again to remote distances. The greatest recent comet of this kind was the " Daylight Comet " of 1910. A small proportion do not go far into space but return regularly, having apparently had their motion in approach to the Sun slowed down by a chance passage near one of the greater planets. Some eight or ten are thus definitely allotted as " captures " to *Jupiter*. The most famous of all the comets is Halley's, which recedes considerably beyond the orbit of *Neptune*, and revolves in a period of about seventy-five years, a period that varies according to chance encounters with the planets. Its return cannot be identified to a matter of five years without taking account of such perturbations. Yet they have been followed, with the help of Chinese and Japanese chronicles, back to 87 B.C. The most notable historical return is that figured in the Bayeux tapestry, contemporary with the Norman Conquest. The latest was in 1910, when the comet was a magnificent object for those favourably placed to observe it.

The nature of comets is imperfectly known. As they approach the Sun they are at first inconspicuous in appearance, presenting a hazy spot of light, so that Herschel first announced *Uranus* as the discovery of a comet. They grow in brightness and develop a bright condensation in the head and a tail, directed away from the Sun, sometimes of gorgeous proportions, and apparently consisting of matter ejected. One would suppose that a periodic comet of many returns would become exhausted in consequence, but Halley's comet hardly confirms this view. The tail is greatest after the passage past the Sun and diminishes as the comet recedes again. Not a few comets have been known to split into two, three or four parts, each following an orbit. The orbits of some comets are identical with orbits followed by certain swarms of meteorites, which we become aware of when the earth chances to encounter their stream and they show as " shooting stars " in our atmosphere. About a hundred known streams, with or without accompanying comets, have been identified. The mass of a comet is very small. When the comet is incandescent, the source of its light can be determined, and carbon monoxide and sodium have been detected besides reflection of sunlight. But these pieces of information are mere scraps—evidences of ignorance rather than of knowledge.

GRAVITATION

That the bodies of the solar system behave in a particular way, the greatest body dominating the motions of the rest, permits of a more comprehensive statement. Newton derived from this fact the law that matter attracts matter, particle by particle, with an intensity that diminishes as the distance increases, just as though a constant quantity had to be spread over an increasing surface. Though that discovery dates from two centuries ago, the theory is so well knit that it repays some detailed survey.

Most natural " laws " are accepted tentatively, until some better statement can be found. But the response to Newton's formula, wherever it was applied, seemed to be complete. The law was first indicated by

the motion of the planets round the Sun, which might all, somewhat roughly, be treated as condensed points of matter, but Newton tried the wide assumption that the law was exactly true between all particles at all distances. Without pausing over the details, it may be said that this justified itself completely. It appeared for a long time that astronomy required and permitted no other formula. It seemed as if all the known phenomena—planetary perturbations, the intricate motions of the Moon, those of the other satellites, those of comets also, the movement of the Earth's polar axis, the determination of its figure and the variation of gravity upon it, the tides—gave no indication that there was anything to add to it. The labour of examination, throughout two hundred years, became greater and greater, but it was sustained by the confidence that nothing else was required.

Apparently the law extends also to the stars. In some cases, as for example when one star is known to move round another, an essential element in the verification may be wanting. And in the case of those groups of stars known as moving clusters, the distances may be so great that the operation of gravitation is insensible. Still no reason is found to call the law other than universal. Incidentally we may remark here on the illustration of the debt of general science to astronomy. The study of force, and the motion it produces, is more general than its astronomical applications. But except in the isolations of the heavenly bodies, examples could not have been furnished of verifiable motions in curves, and of the complicated rotation of a body about its own centre of gravity, whether free or under the action of forces. This is an earlier example, of which physics is now supplying many, of the necessity of astronomy to science in general.

The well-known example of the discovery of *Neptune* is an indication of the certainty of astronomical calculation. The planet *Uranus* did not conform to the orbit first assigned to it. A revision of the orbit failed in the same way. The departures were analysed independently by Adams and Leverrier as perturbations produced by an unknown planet and they succeeded in assigning a direction to this body, close to which *Neptune* was actually found. If the effect of the new body was included, the anomalies of *Uranus* were almost effaced.

But at the present day, we have had a still further example instilling confidence. The errors of *Uranus* were almost but not quite effaced. A certain systematic character in them convinced Percival Lowell, among others, that they denoted the action of a further unknown body, and by unsparing labour he assigned a place and magnitude to it. He felt so much confidence in his work that he provided after his death for the prolonged search that was necessary. A dozen years later (1930) a body was found agreeing quite strikingly with his forecast. He was wrong about its magnitude only, and that delayed success in the search.

This new "planet," *Pluto*, is in many respects unique. It is unquestionably a member of our system, circulating round the Sun. It is not a comet, for no comet is visible so far away. The older planets adhere pretty closely to a single plane of movement and to nearly circular orbits, with the exception of *Mercury*, which moves distinctly out of the common plane and in a very elliptical orbit. But *Pluto* shows more peculiarity in

both respects. It would be easier to find its parallel among the minor planets or asteroids. Possibly it is only the first of a chapter of exceptions. There are some thirty million objects as bright as it is. Most of these are probably stars, but they have never been examined. There would be no reason for surprise in a new ring of asteroids beyond *Neptune*.

What is the nature of this tie that binds matter to matter? Or again, what is matter, if we take this tie as defining it? The only, and great, advance towards answering this question has been made in our own time, by Einstein. Needless to say it cannot be described rigorously while avoiding technicalities. The question is one of general physics, but again astronomy played an essential part in supplying a foothold for theory.

Einstein had developed an electrical theory which linked together space and time and made mass dependent upon the velocity with which it moved. It was frankly revolutionary, and though it fitted in with some indications from the difficult region of atomic theory, it might seem to have no bearing upon well-tried sciences like astronomy. But there was a known phenomenon which astronomers were unable to explain. When all the older forces and sources of disturbance were reckoned, the planet *Mercury* did not go as it might be expected to go. The point where it passed nearest to the Sun showed a minute shift, that nothing known would account for. Here Einstein entered, with the breadth and boldness that characterise all his work, and showed that the unexplained motion could be caused by the mass of *Mercury* varying with its velocity, just as that of an atom did. The revolution of ideas must be appreciated. A crevice had at last been found in Newton's law of gravitation. Mass, which was treated as a primary property of matter, now became a secondary one. Confirmation was given to the view that the primordial stuff of nature was not matter, but electricity.

The theory from which Einstein proceeded indicated that time and space meant different things to different observers. To any one observer they appear easy to distinguish from one another. But we are unable to carry over the identification from one observer to another; there is no test by which we can try it. This is sometimes expressed by saying that we are quite unable to *prove* that any two events are simultaneous. Therefore if the phenomena are described over again in terms that do not assume time and space to be separate and real entities, with a meaning absolute and the same to all observers, nothing that is observable will be lost and some liberty of interpretation will be gained. Einstein accomplished this work of re-describing the phenomena, and it was a feat of genius. He included in the scheme the phenomena of gravitation. The result is his General Relativity.

So many things are taken for granted by all of us, which General Relativity dismisses as prejudice, that it is difficult to convey an idea of what remains. The amalgamation of space and time transforms all our conceptions, and leaves only a geometry of more than the three familiar dimensions. Gravitation even appears as a consequence of local twists in this geometry, the occasion or the cause of the twist being the presence of matter, or rather of energy, of which matter is one of the manifestations. Force is wiped out. What energy is remains unanswerable; it is primal and there are no terms in which to explain it.

By this one piece of mathematics, all conceptions of time and space, supposed fixed, have been demolished and not replaced. The present writer may however record his conviction that, great as may be the extension of ideas and of power that Relativity has brought, until some way has been found to include electrical and magnetic phenomena in its scope, it remains essentially a geometrical *tour de force*, missing its veritable aim.[1]

THE SUN AMONG THE STARS

We are far from an end of what we have to learn from the solar system. The discovery of the planet *Pluto*, and, even nearer home, the unforeseen constitution and importance of the Earth's upper atmosphere as shown by meteorites, and by the transmission of radio-phenomena, prove the fact, if there were any doubt about it. Still, in an outline, which must indicate less the minute anatomy of the subject than its greater members, we must recognise that the stars, and not our nearest neighbours, claim attention. Our goal is to describe where the stars lie, what they are, and what systems they compose. But on many important points opinion is hardly settled. There are great technical difficulties. I shall attempt to indicate them in the course of these pages. The wonder is, that so much is sure. But not to exaggerate the authority of our statements, the best course will be to follow generally the historical development.

Describe the stars then, just as they appear upon the sky, first to the unaided eye, and finally to modern resources of registration. They are very evidently of different brightnesses, the so-called " magnitudes," and less evidently of different colours. Ptolemy, who worked with an arithmetic founded on the number six, as ours is founded on the number ten, divided those visible to his eye into six " magnitudes," each fainter than the last. This system is still kept, supplemented only to render it an exact tool. We fix a standard first-magnitude star. We define the advance of one magnitude as equivalent to a diminution of light 2.512 times. This is near the old estimate and implies that a star is scaled five magnitudes further down if its light is diminished 100 times. Hence twenty magnitudes meant a fall of intensity of light 100 million times. Such faint stars can be reached, but only with the most powerful telescopes and the longest photographic exposures. They are quite beyond the eye, even with every aid.

The brightest stars are few and well known. As we proceed down the magnitudes they become more and more numerous. Presently we have to be content with small sample areas, selected in all parts of the sky. Great care is necessary in choosing and counting these samples, and great care has been devoted to it. Finally, however we proceed, even counting must be given up. The numbers show no sign of stopping, but they outrun our resources of registration.

The counts and estimates may be put in a table as below, where the numbers given represent the stars that are met with if we go as far as the magnitude *m* (visual) given alongside.

[1] The theory of Relativity is discussed in the Article on *The Physical Nature of the Universe*, p. 99.

NUMBER OF STARS BRIGHTER THAN VISUAL MAGNITUDE *m*

m	Number	*m*	Number
4.0	530	13.0	5,700,000
5.0	1,620	14.0	13,800,000
6.0	4,850	15.0	32,000,000
7.0	14,300	16.0	71,000,000
8.0	41,000	17.0	150,000,000
9.0	117,000	18.0	296,000,000
10.0	324,000	19.0	560,000,000
11.0	870,000	20.0	1,000,000,000
12.0	2,270,000		

In reading this table, it must be recalled that these are ordinary stars and do not represent the great clusters and groups which will be dealt with later and separately. If we make an attempt to arrive at a total, we must guess at the number that are beyond our counting. There is very little ground for saying they converge to a total at all. The rate of increase falls off a little, but this may be due, in whole or in part, to general absorption of light on its way to us. It seems as if we were safely within the mark in saying there are ten thousand million, or even a hundred thousand million stars separately registrable and on a par with our Sun. Perhaps no single fact in all our knowledge is more impressive.

Obviously the apparent brightness of a star will change with its distance. If we suppose the stars to differ in actual or intrinsic brightness according to any rule, but to preserve the same proportions at all distances, it appears that for each step of magnitude the number of stars would increase slightly less than fourfold. Looking at the numbers above, we see that the increases in number for one step in magnitude begin about threefold and fall gradually to less than two. The conclusion is that the distribution is thinner as it grows more remote. Apparently we belong to a very numerous cluster. Whether there exist other similar clusters outside our own is a question that will engage our attention later.

That there is a system of an extensive kind, of which apparently we are a member, is evident even to the eye. The "*Milky Way*" or *Galaxy* proves it. This broad band goes right round the sky, somewhat irregularly it is true; the Sun lies close to its central plane. Moreover it is evident on inspection that the apparent density of the stars increases progressively as the *Galaxy* is approached, quite apart from the great multitude of indistinguishably crowded stars that give it its name. The impression conveyed to the eye is confirmed when we arrange the full counts of stars according to distance from the galactic plane. We then find that there is an unquestionable progression. For stars of the fourth magnitude, there are about four times as many near the galactic plane as at its poles; for the twentieth magnitude, about forty times as many. We may conclude that the system we are describing is decidedly flattened, as Herschel concluded, something of the shape of an ordinary magnifying lens, the *Galaxy* lying around the rim and our Sun near the centre.

A less obvious method of investigation than mere enumeration, one of

which the ancients knew nothing, and the value of which increases cumulatively as time passes, is the study of the motions of the stars among themselves. The "fixed" stars are far from fixed, putting aside those larger motions which are actually not a shift of the stars, but of the Earth, the pole and equator of which must be used as data for measurement. Out of a careful comparison of each catalogue of star-places with any earlier one, a number of "proper motions" is derived for the stars that figure in both catalogues. Until we know something about the distances, these are merely changes in the directions in which the stars must be looked for. Naturally they differ pretty widely in amount. A relatively large motion almost certainly indicates a relatively near star. The largest known motion is that of "*Barnard's Star*," which moves one degree, or the 360th part of the circle, in 360 years and turns out to be 400,000 times the Sun's distance away.

But let us rather speak of what emerges when we analyse the motions all together, and individual features are allowed to cancel one another out. In that case a certain definite residue remains, which we may attribute to the mass of the stars, or to the Sun or, more properly, we may take it as defining the Sun's motion relative to the mass of stars. It is directed to a point in the constellation *Hercules*.

If we take into account also the known distances of some of the stars and so convert their apparent change of bearing into linear motion along the celestial sphere, we can measure the solar motion as well as assign its direction, and it is about twelve miles a second. Though we assign this motion to the Sun and not to the mean of all the stars, it is merely a relative motion and there is nothing absolute about it. If we were able to compare the mean of our group of stars with the mean of another group, we should expect to find that they were also in relative motion with respect to one another, and we would be unable to give a meaning to anything absolute.

The solar motion is not the only systematic motion that emerges from an analysis of proper motions of the stars. If it is removed, the remaining motions are not random. There remain two preferred directions, which we know as "the two star streams." The points to which they are directed are opposite to one another, in the *Milky Way*, one in *Orion* and the other in *Scutum*. How many stars belong to these streams is not certain, but the number is very large. It may be the whole of the local cluster. Whether they are best described as two streams is not known, for there is an alternative way of putting the same fact. But the fact remains, whether we call it streaming, or preferential directions of spreading.

Less extensive systems have been detected, which are characterised by common motion. The first to be found was the *Taurus Cluster*. The clustering of stars in the *Hyades* is not illusory. They possess a common motion. More than that, a common motion links many unexpected but prominent members in other parts of the sky, such as five of the stars of the *Plough* with *Sirius* and a number of others.

All these apparently are threading their way through our system, and have been, for countless ages, without suffering any perturbation from other stars or even perturbing one another so as to converge—so feeble must be the gravitational influence of one star upon another.

Another point of view of stellar motions deserves mention. The first common effect to emerge is the motion of the Sun, as said above. If we regard it as a relative motion belonging to the stars, its amount, as a change of bearing, will be more or less according to the distance. But distance shows also in brightness, and though individually no connection may appear, if we take sufficient numbers a correlation will be shown between brightness, or " magnitude," and the solar motion, regarded as a change of bearings, and since we know what the solar motion amounts to this again may be interpreted as a determination of the actual average distances to be associated with a certain average magnitude. Such average distances prove to be quite reliable, and are an illustration of the collateral methods by which astronomers keep their scale in control.

All the foregoing conclusions suffer from the difficulty that the material becomes less and less palpable as the stars get more remote. Unless determinations of angular motion were cumulative and increased in precision with the lapse of time, they could hardly be used at all. Wonderful as it seems, there is another method, by which linear motions in miles per second can be found, and that irrespective of the distance of the star. This is due to the fact that light is transmitted in waves carried with a certain velocity, and a relative velocity of the source appears to the receiver as a change in the wave-length of the light. Such a change can be measured very accurately, so that motions of stars in the line of sight can be found, within less than one mile per second. Needless to say, a method such as this has many applications, some of which will be mentioned hereafter. In the present connection it will be seen how exactly it serves as a complement to the other method. All general conclusions that we derive from the one, such as the determination of the solar motion, can be derived otherwise by the other, in such a manner that the two methods check one another.

NATURE OF THE SUN

Leaving for the present the question of the distribution of the stars in space, we shall return to certain aspects of it after some discussion of their constitution.

We look to the constitution of the Sun, apart from any interest it may have in itself, as the best approach for understanding the nature of the stars. It is to be expected that we should learn a great deal more by critical examination of the phenomena of the Sun than by mere inspection, but it is surprising how great is the difference.

First regarding the Sun as our source of heat, the radiation received at the Earth may be estimated in different ways. It may be taken in the mass, receiving it in a carefully constructed absorber. After somewhat elaborate allowance for the part trapped in the atmosphere, we find that enough reaches each square centimetre of the outer atmosphere of the Earth to raise a gram of water 1.95° C. per minute. Calculating the temperature of a globe of the dimensions and distance of the Sun that would produce this, we find it a little below 6,000° absolute.

Or again, the heat received may be analysed, in respect to its intensity and according to its wave-length. It is then found that it agrees fairly well,

though not perfectly, with the emission of an ideal radiator at a definite temperature—for which alone we can make a binding theory. The temperature of this radiator would be a little above 6,000°. No exact agreement can be found; the emissions are too strong at the red end and too weak at the violet. But the discrepancies are minor matters and leave us with a fairly well determined figure.

For information about the Sun, the spectrum is our chief document. If a small patch of sunlight is passed through a prism, it is spread out into a coloured band. The different colours designate different wave-lengths or types, so that the band is in effect an analysis of the source of light, and may be used to compare the intensity of emission for all the various types. This is the way we compare the Sun with an ideal radiator at a definite temperature, for such a radiator emits the different types or colours, as blue, yellow or red, with intensities that are characteristic of its temperature. But we can do much more than estimate the balance of intensity for different colours. Sunlight reaches us deprived of some very significant elements. The spectrum, if produced by a narrow slit, is not continuous but is crossed by many thousands of dark lines, some exceedingly thin and faint, some broad and heavy, some sharp, some fuzzy, in apparently inextricable complexity. It constitutes the most precise as well as the most precious document in physics, and it has taken the better part of a century to unriddle it. It was found that these lines were characteristic of the chemical elements. The first thing learnt was the presence of sodium in the Sun, followed by the detection of about half the other elements, by recognition of the characteristic lines emitted by these elements. The lines are produced by a kind of contrast, when the element is present as a screen of lower temperature between us and the luminous disc. Hence we cannot prove the absence of an element from the fact that its lines do not appear, since it may be present low down within the luminous disc. The quality of the lines, their breadth, their intensity, has much to teach us of the state of the atoms that emit them, and therefore of the state of matters within the Sun itself, but this is best deferred until we can consider it in comparison with other stars.

Some features however we may deal with. If the element is in motion in the line of sight, the lines are displaced. For example, the Sun rotates, the east limb approaching and the west limb receding. We can measure the effect, and verify that the angular daily motion falls off from the Sun's equator up to 75° latitude, so that a complete rotation which takes place in 24.7 days at the equator, occupies as much as 33 or 34 days so far north or south as we can trace it.

But besides this constant effect, many local motions are shown, and some are exceedingly violent. The face of the Sun that we see is in furious turmoil, tempests raging to and fro with speeds like the volleys of an explosion. More systematically they show as whirling movements around the "Spots." These spots, not yet fully understood, are dark, or relatively dark, regions of lower temperature, that drift with the surface, and seldom endure more than a couple of months. A counter-clockwise tornado around a spot in the northern hemisphere is not infrequently associated with a clockwise system in the southern. They partake in the "periodicity" of the Sun, of which indeed they are the chief measurable indication.

This so-called periodicity of the Sun, though not prominent, is apparently deep seated, and can hardly be different in character from the much more pronounced recurring change that declares itself in many stars. Besides the spots, it is seen also in various other solar phenomena, in the "prominences," the type of the "Corona," and the magnetic effect of the Sun upon the Earth. It can be traced back almost as long as spots are observed. Perhaps because of the casual, unsystematic nature of the early records and the difficulty of tracing anything regular from the spots, the tale is far from smooth, but a chief period of 11⅛ years is clear, with a rapid rise from the least number present to the greatest, followed by a slower fall, broken half way by a pause. In this respect it resembles the characteristic type of change that is observed in much more pronounced degree in certain stars (p. 131).

The Sun presents to us strata as definite as, though different from, the gaseous, the liquid and rocky cloaks of the Earth with its unknown core. Starting from the interior, which only theory can penetrate and where circumstances must be very different from anything in our experience, we come to the opaque region known as the photosphere. It is from this that we receive radiation, for by some process the photosphere blankets the radiation from within. It is itself gaseous, but visibly also it is sharply bounded as, for example, is a cloud. Temperature and density fall, presumably, as we proceed outwards and only the lighter elements in the upper strata can announce their presence by spectral "lines" of absorption of hotter radiation from below. Some of the lines are of such a character that we can use them instrumentally so as actually to map the distribution of that species of atom in the Sun. Calcium, robbed of one electron, and normal hydrogen are thus continually charted. The calcium floats in bright patches or "flocculi" in the Sun's atmosphere, being specially dense over the spots. The chief character of the hydrogen distribution is found in immense trails of lower radiation. These are associated with "prominences," which are mainly jets of hydrogen—if anything going through its sequence so fast can be called a jet—into the relatively non-luminous upper strata. Relatively only, for there appears, when the disc is eclipsed, a streaked "corona," with no sharp boundary, and following in its changes the Sun's period of variation. In this corona the light gas helium was first discovered, and another which has been identified with oxygen in one of its "forbidden" states—forbidden, that is to say, or not occurring in our laboratories, where the atoms are still so close to one another that we can experiment upon them.

We think of the Sun's radiation as light, but as to how light travels our theories are only tentative. Certainly we must include, among what reaches us from the Sun, streams of electrified particles, which reach our upper atmosphere, being diverted towards the magnetic poles, to reveal themselves there in *Aurora Borealis* and disturbances of the earth's magnetism. The Sun itself is a magnetised body, with a general magnetic field, specially intense about the spots. Presumably this is no more than to say that the atoms that are found there are torn, temporarily, apart.

The mass of the Sun, which dominates the motions of the whole solar system and is felt beyond the orbit of *Neptune*, must be regarded as synonymous with a concentration of energy in a certain portion of space.

It is now held that as the Sun radiates energy—of which we receive a minute portion, a hundred millionth—its mass diminishes by four million tons a second.

The relations of mass with radiation are fundamental in the theory of Relativity. They were stated by Einstein before they were observed, in two other features. The gravitational field of the Sun disturbs the transmission of light. This was verified and measured by Greenwich observers in the eclipse of 1919. And the density of the Sun lowers the tone or, which is the same thing, makes redder the emission from all its atoms. It is difficult to detect this in the Sun, because the effect is small, and is over laid by other phenomena, but when we come to certain stars, the fact springs into cardinal importance.

THE SUN COMPARED WITH THE STARS

Having thus formed a descriptive idea of the Sun, we must next control or correct the presumption that it is a characteristic star. It may be said at once that the stars divide into two series or sequences—the so-called " Giants " and " Dwarfs." The Giant Stars will occupy us later. The Sun belongs to the other sequence, known as the Dwarfs—rather unfortunately, for a dwarf is an exceptional individual, and there is nothing exceptional in the Dwarf-series, nor are its members specially small. However, the term is established and we must use it, though we shall refer to it usually as the " Main Sequence."

The Sun's magnitude on the stellar scale, found by reducing its light suitably, is —26.7, understanding by a " magnitude " a step in intensity of brightness of more than 2½-fold, as explained above (p. 121). That of *Sirius* is —1.6, *Vega* 0.1, of *Altair* 0.9. It is so bright only because it is near. As we wish to compare the stars irrespective of their distances, we must introduce a conception which eliminates distance, by placing them all at a standard distance. The standard distance usually taken is about two million times the radius of the Earth's orbit—10 " parsecs " or thirty-three light-years, as they are called—taking a " light-year " as the distance which light would travel in one year, *i.e.* about six million million miles. The magnitude as viewed from this distance is known as the " luminosity " of the star, or sometimes as the " absolute magnitude." The luminosities of the stars named above are as follows : the Sun 4.9, *Sirius* 1.3, *Vega* 0.6, *Altair* 2.9 ; and this is fairly indicative of conclusions from fuller data—that the Sun is a normal star of rather low luminosity.

Before remarking upon these figures we consider other features. The light of a star can be analysed, in the same way as that of the Sun. Spectra can be obtained for the stars, just as for the Sun, though naturally with less detail. However, they make it very clear that a spectrum of the solar type is only a stage in a long series or sequence. They are divided into classes, to which names have been given—O, B, A, F, G, K, M, N, R. The classes merge into one another insensibly. The Sun belongs to class G. The classes may be distinguished approximately by colour, as blue (B), white (A), yellow (G), orange (K), red (M), deep red (N) or (R). More precisely they may be defined by the character of the spectral lines. From class O, bright lines are emitted. Class B form the helium stars,

and show slight and faint absorption lines of any kind; in class A the hydrogen lines have developed to enormous strength, and metallic lines show their presence, especially the lines of "ionised," or electrified, calcium, called by their discoverer Frauenhofer (H) and (K). This (K) has nothing to do with the K-stars. In class F these are much developed and the hydrogen lines recede. Class G continues this process, and in particular the lines (H) and (K) are very heavy and broad. Class K shows even more absorption lines, the beginnings of general absorption and absorption in bands by certain compounds. Before this stage, chemical compounds, even the most refractory to heat, hardly declare themselves. In class M the general absorption increases, and in particular the spectrum is deeply gashed by a succession of bands that have been traced to the oxide of the metal titanium. The conclusion is inevitable that we are looking at a sequence, though whether it is a mass sequence—state depending upon size—or a time sequence in which each star passes through all the stages in succession, or whether there is some connection between the two ideas, must be left for further investigation.

Besides showing a progression in the development of the lines, the spectra show a variation of intensity in respect to the balance between the blue and the red ends. This feature, shown in a rough, but quite consistent way in the visual colour of a star, may be measured accurately by more refined apparatus. An ideal radiator would show a known and calculable balance of colours for each temperature, and we have seen that the Sun roughly approximates to an ideal radiator at a temperature of 6,000°. By assuming that the stars do the same, we can find their temperatures also, and those for each spectral class are now well established. A table is given below, with some further details (p. 133).

With regard to the masses of the stars, compared with that of the Sun, the evidence is sufficiently striking, though there is not very much of it. If collisions occurred between stars, mass could show in the effects, but as they do not, mass only shows in gravitation. No planets can be seen circling round the stars, and according to the current view, such a planetary system as surrounds our Sun exists only by the rarest accident. But a number of cases are known in which two *stars* circulate round one another, evidently by their mutual attraction. In fact such systems are of very frequent occurrence, and many more must exist than can be detected if we are to rely upon seeing the two components separated from one another, for it appears from theory that fission into two is a normal incident in the development of a star. If the motion of a double star has been followed over a sufficient portion of the relative orbit, and if in addition their distance from us has been ascertained, gravitational theory allows us to assign the sum of the masses of the pair. If, further, their motion can be followed separately by comparison with some independent standard, the masses can be separated from the sum. We conclude that a good many conditions must be satisfied before we obtain well determined masses, and it is not surprising that comparatively few are known with certainty. Few as they are, there is little doubt as to what they say. They show that not only is the Sun a representative star of its own spectral class, but that right through the main sequence, at any rate if we stop short of B stars, the masses exhibit a very small range. No star is known

with a mass less than one sixth of the Sun, and this one is at the extreme red end of the sequence. At the other end, *Sirius* is about two and a half times the Sun's mass, and this is exceptionally big. If we arrange the masses according to the luminosity an even more striking result is apparent. But as this includes also the giant masses, as well as other outlying cases of high theoretical importance, detail with regard to it is deferred.

GIANT STARS

The increase in the masses of the stars as we pass upwards in temperature, from class A to class B, and beyond these to O, is very marked. Those at the top of class B are ten or twelve times as massive as the Sun. The highest known mass, by far, is of class O; the star has two components, each probably 100 times as massive as the Sun. Concurrently the mutual orbits from which these masses are derived exhibit a progressive change. Those first found with the micrometer, the astronomer's instrument for measuring their visual separation, are of long period—very few being under a hundred years—and very elliptical. As we proceed to the other end of the sequence the period, and with it the distance of separation, diminishes and also the ellipticity of the orbit diminishes. The view is strongly suggested that we are viewing stages of a process of development, which begins with the "early" stars of high temperature and mass, and, therefore of high luminosity, and continues down the main sequence, the mass gradually diminishing and the temperature falling, while the components of the "binary systems"—as we call a pair of stars circulating round one another—separate and circulate in more eccentric orbits.

The binary systems of *short* period are not revealed by the older methods of measuring separation and relative direction of two components with the micrometer. The two components are seldom distinguishable even as an elongation in the image. They are shown instead by periodic oscillations of the spectral lines about a mean place, defining a to-and-fro motion of the emitting body in the line of sight. Such systems, as has already been remarked, are very numerous. The method is another application of motion in the line of sight showing itself by a change of wave-length. Sometimes both spectra are visible and, not infrequently, are of different classes. What we can derive from such observations is restricted in the important respect that we cannot distinguish the inclination of the orbit, and the true dimensions are involved in this deficiency. On the other hand, we are given direct velocities without demanding a knowledge of distance.

It will appear below that these giant stars are, some of them, of enormous size. The star *Betelgeuse*, if placed where the Sun is, would extend to the orbit of *Mars*. This is exceptional, but it must be evident that two suns of this kind, revolving round one another in a few days, must frequently be in actual contact, or even intermingle their bodies, under which circumstances their differential gravitation, which is known as the tidal effect of one upon the other, would be of an order comparable with the main gravitational effect. This gives peculiar importance to another source of knowledge of certain systems, exceedingly precise and leading

in certain cases to most valuable pieces of information not to be obtained otherwise. This is by the study of the light changes of pairs of stars that pass in front of one another and so eclipse one another.

Some, indeed many, of the stars vary in light. In some cases it is certainly due to an actual change in the star itself. In others it is equally certain that we happen to be in the plane of circulation of a close binary system and receive the light from the two discs, now separated and now hiding one another. Thus there will be two equal maxima of light, and two minima that will be unequal, if, as usually happens, the stars are unequal in size and brightness. The best known star of this type is the star *Algol*—*β Persei*—which in five hours loses two-thirds of its light, recovers it again in the same period, and remains at full brightness (with a slight secondary minimum that can only be detected by an instrument for measuring brightness) for 2¾ days, after which the same steps are repeated with perfect regularity. We are viewing an eclipse, and as the distance of *Algol* is known, by analysis of the phenomenon, we can tell the sizes of the discs of the two stars, as well as the masses. The important new fact that this approach gives us is the density, and this star turns out to be of low density—if not gaseous—about one-eighth that of the Sun, or one-sixth that of water. Other systems, also well observed, give much lower densities, some of them some hundreds of times less dense than air. Yet these huge spheres of gas, which are only distinguishable from a void by the greater void around them, emit light themselves and eclipse the light of each other.

Thus we must think of stars *preceding* the main sequence upon which the Sun is found as of greater mass, vastly greater luminosity and low density. But they do not progress continually to greater and greater effective temperatures. Theory would dictate that they reached a maximum of temperature after which they turned back, and this appears to be the case. Preceding the main sequence, where the order goes from B to M and the temperature falls in consequence, and uniting with it, say, at class B, we have a giant sequence of great stars of round about the same luminosity, which run through the whole series of spectral classes in the reverse order—that is to say from M to B, with rising temperature. A gap of at least twelve magnitudes separates the stars of class M, which are here at least true giants and true dwarfs. The M-giants are among the brightest, and the M-dwarfs among the faintest objects in the sky.

VARIABLE STARS

The eclipsing stars which vary in light, of which we have spoken above, owe their variation to the geometrical accident that we happen to lie in the plane in which they revolve round one another. But there is a true variation of light in a great many stars, in some cases regular and in some irregular in all degrees. Regular variation is illustrated by the star *δ Cephei*, whence we derive the name "the Cepheid type." The period of Cepheids ranges from about 100 days downwards to a few hours, and change in the period of a single star has hardly been established. The stars in question are among the greatest that we know. These very great ones are giants of class G, and of very low density. Those of

earlier class are smaller and of shorter period. The luminosity may change from a barely sensible increase, up to more than double the minimum light emission. The change of brightness shows the feature of rapid rise to maximum and slow fall, punctuated by a hesitation. It will be recalled that the Sun's periodicity displays this also, though any attribution to a common cause is merely a speculation. By measuring the wave-lengths from known lines of the spectrum, we find that the radiant surface is approaching us and the temperature rising when the light is increasing, and receding with falling temperature when the light is diminishing, suggesting so strongly a pulsation within the body of the star that this is the generally accepted explanation.

The period of a Cepheid variable is intimately connected with its luminosity. This was first established by the discovery of a number of them in the smaller " cloud of Magellan," which is a remote group containing almost numberless nebulæ, clusters and systems, a veritable " island universe," where presumably any Cepheids that occur are at about the same distance from us so that their true luminosity follows their apparent magnitude. Though we have no explanation for it, this period-luminosity relation is so definite that it is used without question. And it has this important use—since it covers the periods of Cepheids in our own large cluster, which are remote stars certainly but not inaccessible by one means or another—we can translate the apparent magnitude of the others into absolute magnitude, and thus use in effect the immense distances of δ *Cephei* and *Polaris* and others which are not too remote as a new measuring rod for sounding the further depths of space. We shall have occasion to refer to this method again later.

Much less regular are the " long-period variables." The long periods are not very long, ranging from 250 to 1,000 days. Unlike that of the Cepheids, the variation is not so definite that it can be foretold with certainty, but when it comes it may amount to a change of many magnitudes. Thus the star called *Mira* (ο *Ceti*) frequently increases in brightness two-hundredfold or more, and this is not the greatest difference known. These stars, like the Cepheids, are great stars (though not so great) and of very low density. They are of low temperature and advanced spectral class, but they appear to be distinct from the Cepheids, and not to form a continuation of that sequence.

The Cepheids and also the long-period variables are often viewed as more or less regular pulsations in the body of the star. A third class of variation is more adequately regarded as an explosion. These are the Novæ. As a rule, though not always, such stars are known to break out only once. Some very faint star which has been, for all we know, steady and normal, increases its brightness perhaps a hundred-thousandfold in the course of two or three days and soon settles back, more slowly, into its old insignificance. Hence the disturbance, whatever its cause, must be called superficial. Meanwhile the spectrum shows, as might be expected, a tumultuous sequence of changes, but proving by the displacement in wave-length of the lines that can be recognised, that the luminous gases are rushing towards us as by an explosion. It is extremely improbable that it is anything else. It might conceivably be a collision, but all the stars are so small compared to their distances apart that a direct collision would

occur practically never. Now the phenomenon of a Nova is not uncommon; a good many Novæ break out every year. Very few are remarked at the time, because great brightness is necessary at maximum in order to attract attention; the fact is established by examining stored photographic plates, covering the same region, where the steady brightness and sudden outbursts are found recorded.

The review in the last three sections of the nature of the stars will show that knowledge of the Sun is merely a key to the door, and though it is an indispensable and effective key we find, when we use it, that it opens to us a variety of unforeseen things.

NATURE OF THE STARS: OBSERVATIONAL

Following the idea expressed in the last paragraph, it might seem that the ground was insecure, when we came to describe the physical states of the stars which differ widely from the Sun or any matter we know upon the Earth. But astronomers hardly feel it so. Reference has been made more than once to the way in which one undemonstrative conclusion, perhaps little more than a surmise, serves to strengthen another of independent origin. Almost all the observations of the physical state of the stars are separately incomplete in this sense. But we piece the puzzle together and in the end get a picture which is not likely to want any large changes in order to put it right. This practice is well illustrated in what follows. We begin with stellar temperatures.

The temperature of the Sun may be derived from the whole heat received at the Earth, or from the same analysed according to its quality or wave-length, or again by consideration of the wave-length at which the intensity of emission is a maximum. All these depend upon well-established physical theory. They agree in indicating a temperature of about 6,000° absolute, which may be imagined as belonging to the opaque luminous disc at the base of the thinner solar atmosphere. It is undoubtedly gaseous there, but it is opaque; we get nothing from below it and can only penetrate it by theory.

Taking, now, what evidence we can about the stars, we may photograph their spectra and examine the variation of intensity as we proceed along it. Variation introduced by the method of reception may be allowed for, and the outcome is a curve of varying intensity that can be compared with that of the Sun, and assigns a temperature accordingly. Incidentally it confirms the supposition, suggested by observations of the Sun and also by theory, that the whole radiations of a star follow pretty closely those of the ideal radiator—the so-called "black body" of the physicist. The method permits of extension. Full spectra can be obtained only over restricted magnitudes, since the light must be spread out and therefore weakened, before a spectrum is recorded. But ultimately it is only the balance of intensity between the blue and the red that we require, in other words, the united effective balance of colour of the light considered as a whole. Accordingly a quantity called the "colour index" is studied, which may be found if we compare the magnitude of the star as photographed with that as seen, since the photographic plate is most sensitive to one colour and the eye to another. This can be pushed as far as where

any stellar images will record themselves. It is found that " colour," as it would appear to the eye, or effective visual wave-length, can be assigned definitely. The method fits on to the other method and corroborates it. Further, it deals quite positively with the place where the main sequence of stars splits away from the giants, which occurs about class B. The temperature, in short, is found to follow closely the spectral class, the class of giants being somewhat cooler than the dwarfs of the same class.

Satisfactory as this method is, it is not the only approach to a solution. Actual quantity of radiant heat, spread out over a spectrum, has been measured. Naturally the observation is somewhat of a *tour de force*, and has only been effected with the greatest telescope there is, namely, the 100-inch telescope at Mount Wilson in California, and for a few of the brightest stars only. As far as extending knowledge goes, it affords another prop to what we have concluded otherwise. A definite prolongation of the series is given by a fourth method—the consideration of the appearance, preferably the maximum intensity, of chemical elements which have lost one or more electrons, as they may under sufficient agitation. If the sequence it gives is adjusted to known temperatures in the known region, it extends by a credible theory our knowledge into the unknown, just where the determination by colour or spectral balance becomes ineffective or fallacious. The following table shows approximately the results for the different spectral classes :

B	..	20,000
A	..	12,600
F	..	8,600
G	..	6,200
K	..	4,400
M	..	3,500

It will be remarked that there is nothing very extraordinary in these temperatures. The temperatures that must be assigned *within* the stars, ranging up to millions of degrees, are a very different matter and can be conceived only by theory. But the temperatures given in this list overlap at the lower end what can be dealt with on the Earth in the electric furnace and in explosions. We may regard them as immediately contiguous to ordinary experience. It is therefore doubly valuable that we can use them for another purpose, and incidentally confirm them. When the apparent size of a body is known and also its temperature, we can calculate the radiant emission we receive from it. For the stars, the last figures as magnitude and the first as apparent diameter, which is measured by the angle subtended. In other words, knowing the temperature and the apparent magnitude, we can calculate the apparent diameter. The following represents the results for a few of the brightest stars. For the case of these stars the distance is also known, so that we can find not only the apparent diameter, but the actual diameter. That of the Sun is taken as the unit.

Capella	12	*Vega*	2.4	*Companion to Sirius*	034
Arcturus	30	*Sirius*	1.8		
Aldebaran	60	*Procyon*	1.9		
Betelgeuse	290	*α Centauri*	1.0		
Antares	480	*Barnard's star*	0.16		

These data, obtained first as above from theory, have been confirmed, and along with them the theory from which they spring, by a brilliant piece of direct measurement. It should be remarked that we can never see a true stellar disc, to measure it. It is overlaid by a much larger false disc produced by the scatter of light known as diffraction. Otherwise, though the quantities are small, some of them would have proved to be within reach. Obviously the biggest disc will be one that appears bright though of low temperature. This points directly to *Betelgeuse, Antares* and α *Herculis* as the most promising. But diffraction, which defeats us first by creating a false disc, has been made, by applying it otherwise, to yield up the secret. If the same source of light, proceeding through two apertures, is brought to a single spot, the united diffraction disc is found to be crossed by bright and dark bands, the separation of which depends upon the separation of the apertures. If two sources are presented at the same time, the bands can be made to disappear in the united diffraction discs, by separating the apertures suitably, so that bright of one compensates dark of the other. The two halves of a stellar disc may be regarded as the two sources, and thus the apparent diameter of the star can be measured in terms of the separation of the apertures that give an image free from bands. Though comparatively few stars can be treated in this way, and these with difficulty, it is enough, for it confirms that the diameters calculated from temperatures and magnitude are real; if we want more than these direct measures can give, we can obtain them by the easier method.

There is a further confirmatory value in these numbers. Comparing the diameters derived with that of the Sun, it appears that over most of the main sequence, which is given in the middle column, the diameters do not range widely. They run down a little for the red dwarfs, and run up a little for high temperature stars. But for the giant red stars, to which the last entries of the first column belong, they are enormous. *Betelgeuse*, placed where the Sun is, would envelop the Earth and reach as far as *Mars*. Its volume would be about twenty-five million times that of the Sun. But so far no star has been found, and we do not expect any, with a mass greater than a very moderate multiple of the Sun's mass. Hence we have a confirmation of what we have already concluded from the showing of eclipsing stars, that these great stars must be regarded as composed of a gas as tenuous as would produce a pressure of about a thousandth of a millimetre of mercury. The standard pressure of the atmosphere is recorded in the barometer as the millimetres of mercury, so that the quantity is about a millionth of an atmosphere.

THE ATOM

It is almost impossible to give a lucid account of the stars without positing a knowledge of the structure of the atoms. The two are indeed very closely linked. Many of the details of the modern theory of the atom could not have been confirmed elsewhere than in the great laboratory of the sky. And our sole means of ascertaining the constitution of the stars and nebulæ, and much else about them, lies in splitting their light into spectra and then studying them by the help of a theory founded on terrestrial experiments.

The modern atom is a kind of solar system on a minute scale, too complicated for exact calculation, unfortunately, in any except the simplest cases presented. And here we may remark that though we are in the habit of speaking very definitely, as we do in describing the atoms, of " electrons " revolving round their nuclear " protons " in certain orbits, and so forth, this must be regarded merely as a manner of speech, designed to assist thinking and to point to the execution of certain calculations that work out. The less definiteness we give to our words, the less we are likely to be misled. It will be sufficient if we think of the electron as a particle, beyond conception small, and charged with an invariable quantity of negative electricity, while the proton is still smaller, nearly 2,000 times as massive, and charged with an equal quantity of positive electricity. One or more protons form a nucleus, and an equal number of electrons revolve around them with incredible speed ; and each of the ninety-two chemical elements is characterised by an " atomic number," which is nothing but the number of electrons revolving round its nucleus in its un-electrified state. But there is much in the spatial specification that is obviously provisional, and which we should abolish without compunction if we could find an equally useful equivalent. Indeed it may be regarded as already abolished, and replaced by a " wave theory " which denies any permanent identity to the electron. But like the ray theory of light, which the undulatory theory supplanted, the current description as given above is too useful and too efficient to be discarded.

Any information we have of the constitution of the atoms is got from their spectra. The spectrum of the hydrogen atom is the simplest of all the spectra. It consists of a single series of lines in the visible region, proceeding from the visible red to the ultra-violet, at intervals diminishing in an obviously related manner, until finally the series converges upon a definite limit in the ultra-violet, beyond which the lines cease and a faint continuous band succeeds, extending until lost to view. Similar series of lines have been found in the infra-red and ultra-violet regions of the spectrum, into either of which regions the eye cannot penetrate.

It would take too many words to explain how this sequence, which anyone could recognise, baffled all theory, and finally forced upon us a revolution of ideas more drastic than that of Relativity. This is the " Quantum Theory." We now picture the hydrogen atom as consisting of a single electron, negatively charged, which revolves around a positive nucleus under mutual attraction, the whole being neutral electrically. Our older theories would have said that all orbits were possible for such a system, and the mere description of an orbit entailed emission of radiation. But we must conclude that that is not the case when we are dealing with an atom. Only those orbits are possible in which the so-called " action " steps up *by a certain definite amount, the Quantum*. This quantum is a fundamental unit in physics and, once known, can be detected over and over again as the true and only explanation of many facts otherwise unintelligible. The first orbit is the smallest orbit, of lowest action. As the action is increased by a step, the orbit grows larger by a step, until finally the electron has such a speed that it escapes from the pull of the nucleus altogether, and travels farther and farther away. The

negatively charged electron and the positively charged proton have thereafter separate histories, and the system is said to be electrified or "ionised." The process by which quanta are conveyed to the atom, or from it, is radiation. When radiation strikes the revolving system, it can only be absorbed in definite quanta. When so absorbed, the electron is said to "jump" from one orbit to the next, and the fact is marked to our senses by the occurrence of one of the absorption lines of the spectrum. Such an absorption line, or emission line, therefore records the orbits between which the electron has "jumped."

This complicated and artificial description is forced upon us by the facts. It will be remarked how far it is from classical dynamics, which is a theory of the effect of forces in producing motion, and, like ordinary geometry, is founded upon axioms that are supposed to be metaphysically self-evident.

The hydrogen atom, and the nearly similar one of ionised helium, are the only systems simple enough to be calculated exactly. But, as was said above, the scheme extends itself to all the ninety-two elements; two electrons revolve around the nucleus of neutral helium, three round that of lithium, and so on. The orbits arrange themselves in a symmetrical but peculiar way, in a sequence of "shells," which contain when completed respectively 2, 8, 8, 18, 18, 36 electrons. All the chemical properties and the visual spectrum of each element depend upon the number of electrons in the outermost shell. If one is removed from an inner shell by any cause, radiation may be emitted, and the inner shell completed again by an electron "jumping" from an outer shell where the energy is higher. When the outermost shell is complete in its number of electrons, the element is practically without chemical properties, and we have the inert gases Helium, Neon, Argon, Krypton, Xenon, Radium. Helium is inert chemically and Hydrogen is active, because the two electrons of the former complete the first ring, while the single electron of the latter leaves it open. When an element is reduced by ionising it—that is by driving away one of the electrons of its outer shell—to a certain similarity of structure with the element next below it in the series, its spectrum becomes similar to the spectrum of that element, though the analogous features do not occur in the same part of the visible band. The word "similar" requires explanation. The spectra are too intricate for exact prediction, but they present recognisable features, sometimes very obvious visually, as pairs of lines, or lines in threes or more, the so-called "triplets," or "multiplets" of any complexity, and these are generally reproduced quite faithfully in the spectrum of the next higher element in the series when the latter is ionised.

Ionisation of an element, being the loss of an electron from its outermost shell, whereby it seems to acquire a positive electrical charge, is a very definite step, which takes place only under assignable circumstances. Hence when an ionised spectrum is recognised in a celestial body, it gives information of extreme precision as to the physical state in that body.

The atoms must be regarded as incredibly small and numerous and rapid in action. Unless search is made expressly, we apprehend nothing except the statistical results from the behaviour of great numbers, which

may be quite different from the behaviour of any individual atom. Yet we know something about the behaviour of individual atoms; for example we know that they are not always the same; thus they interfere with one another. The spectral lines corresponding to the larger electron orbits are apt to be fuzzy, which means that they perturb one another and have not strictly the same period for revolving round the nucleus. They can be made sharp again by reducing the pressure, that is to say, by leaving more space to each atom.

As everybody knows, statistics mislead completely if applied to predict individual behaviour. " The unexpected always happens " because the expected, at best, is the average, and the happening is individual. A relevant example may be taken from the exchange of heat between bodies. A body, which is a perfect radiator and absorber, refuses to absorb or radiate indiscriminately, but preserves a balance between radiations of different types, which is related to its " temperature." This fact alone, well known and well established as it is, has been found impossible to explain without resort to a quantum theory, for which it becomes one of the fundamental proofs. Now temperature, viewed more closely, is a measure of the average relative agitation of the particles of the hot body. Hence we should expect, as in fact we find statistically, that a body can take up heat from one that has higher temperature, but parts with heat to one that has a lower one. But if we resolve the particles into chemical molecules and these into their atoms, exchange between two bodies becomes an average history of exchanges between the atoms. Thus if we calculate the temperature, say, of a particle of dust in space, exposed to the radiation of all the stars, it is found to conform to what we should expect in a relatively large body, and to be only a few degrees above absolute zero. But if we treat, not a particle of matter, but individual atoms, these can only absorb or emit radiation in a prescribed way, and if we calculate the temperature at which they are, it is found to be about 10,000°. Of course, though the temperature is high, the quantity of heat may be small.

In the same way we can generally only rob an atom of one of its electrons by somewhat violent means—high temperatures or heavy electric discharges through high vacua—but the isolated atoms that are found in space, and in the upper regions of our own and the Sun's atmosphere, appear to be mostly ionised. We infer that, having become ionised by some accident, the encounter with a neutralising electron is a circumstance too rare to be the rule. We shall see the bearing of these facts in the next section.

CONSTITUTION OF THE STARS IN THE LIGHT OF ATOMIC PHYSICS

The circumstances in the stars are evidently so different from any circumstances we can approach or handle here, that scruple is necessary in drawing any conclusions from them. We must build upon ultimate physical theory, or we shall certainly be led astray. That is the importance to us of atomic physics, which otherwise it would seem so paradoxical to introduce into astronomy. Our confidence in forecasts will be

greatly strengthened by doing so. Accordingly we shall first point to many places, otherwise dark, which the conceptions of the last section of this Article illuminate. Such illumination is due, for, as already remarked, the current theory of the atom could hardly have been established without the evidence contributed by astronomy.

We turn first to the Sun, keeping an eye upon the application of terrestrial physics to its phenomena. We find that a great deal can be read about the occurrence of different elements at different heights in its " atmosphere " from a photograph of the spectrum of the narrow crescent which the Moon exposes just before a total eclipse. The crescent is so narrow a source of light, that in this case we do not need to make it narrower by interposing a " slit." For about a second the disc is shut off while the luminous atmosphere is visible, and as the Moon's disc is then slightly bigger than that of the Sun, it cuts across all the different levels of the solar atmosphere. An element which occurs high up records its presence by a longer line than one that is lower. The elements that are found to reach highest are the light elements hydrogen and helium, which we should expect, and ionised calcium, which might seem surprising, because there are many elements lighter than calcium. Extreme tenuity must be indicated. Even lower down, where neutral calcium also shows, far the greater proportion is ionised, and, for this to be the case, the general density must be low. Other circumstances confirm this conclusion. Since gravity on the Sun is twenty-eight times as great as on the Earth, under parallel circumstances we should have, not a tenuous, but a dense atmosphere. The balancing consideration that must be introduced to counteract a strong gravitational pull is the pressure of outgoing radiation. The mechanics of radiation enter very prominently in any theory of stellar states. Every dark line in the spectrum connotes radiant energy absorbed. A proportion of what is absorbed is re-emitted as radiation, but at a lower temperature, and moreover in all directions in place of directly outwards, so that a residue remains with the atom, counteracting the pull of gravitation. The importance of radiation pressure becomes still greater within the body of a star, and as will be pointed out below, may become the dominant factor, feeble though the force may be under terrestrial circumstances.

Returning to the lower levels of the atmosphere of the Sun, taken as a typical state, the features known as sun-spots, though embedded in the photosphere, exhibit unmistakably a lower temperature, namely about 4,000° in place of 6,000°. The evidence comes from various sources; we have the general balance of emitted wave-length, the prominence of compounds like titanium oxide, cyanogen and hydroxyl, and the relative strengthening or weakening of certain spectral lines. The sun-spots themselves are certainly vortices, or whirling storms which may be the ends of long, whirling filaments, sometimes just breaking out to the surface, and there spreading outwards laterally and lowering their temperature by this expansion. The whirl can be seen in suitable photographs, and the whirling " ions," that is to say, broken atoms, generate a strong magnetic field, which can also be detected by suitable apparatus. The sun-spots recur with a period of about eleven years, but alternate sun-spot periods reverse their magnetic field, so that a full period must be thought of,

not as eleven years, but twenty-two. In less degree a magnetic field has been traced over the whole of the Sun, just as we have a magnetic field over the whole of the Earth, the poles approximating with the poles of rotation, as they do on the Earth.

We have thus good grounds, in confirming what we know, and illuminating its meaning, for pushing further the application of atomic physics, in order to assist our comprehension of the state of affairs within the Sun, and therefore within the other stars. The first problem that meets us is the opacity of the disc. Why can we not see right into the Sun ? It is not due to sudden change of density—there is none. The answer is that it is due to ionisation. An ionised gas will trap radiation, as has been verified by terrestrial experiments, and therefore prevent us from receiving the radiations from within, by which alone it would be possible to see the interior Hence, enormous, by our standards, though the energy emitted by a star may be, it is merely a leak. The main part of radiant energy and of the irregular motion that we know as heat, is semi-permanently trapped within. Now violent motions at close quarters mean electrons frequently displaced, so that we must think of the characteristic atoms as stripped of part or all of their outer shells of electrons. So far as we know they do not lose their identity and, if placed again under suitable circumstances, would speedily assemble the normal shells about their nuclei. But there is a consequence of the first importance. The nucleus is very small as well as very massive. If stripped of its shields, it may and does present densities exceeding thousands of times anything known in circumstances we call normal, though at the same time it has the free mobility of a gas. The density of the Sun exceeds that of water by forty per cent. And it used to be a problem whether its interior was gaseous or liquid. But the density of the faint and tiny F-star that accompanies *Sirius* exceeds that of the Sun 36,000-fold. But since this arises from stripping the outer shells of the atoms, there is no reason to treat either body as other than a perfect gas.

The best theory shows that the temperature must rise within the body of a star to millions of degrees, and as the temperature rises, the pressure of radiation rises enormously too. It rises at a greater rate than gravitation, which it opposes, and accounts for the fact that the stars are not greatly more compressed than we find them and than we should expect them to be from their great masses. At a certain point indeed radiation-pressure would become greater than gravitation, but if that were reached, expansion would reduce it again, and we should have a pulsating body. This may be what we witness in the Cepheid variables. If the circumstances were such as to make radiation-pressure greater still, the star would fling itself apart, so that there is an assigned limit to the size of the collections of matter we know by the name of " star." Or again, we may have a border-line case such as a Nova seems to illustrate.

The luminosity, or shining, of a star is, as has been said above, a mere leak. It may however be calculated from physical theory when the other circumstances are known, and though the calculation is difficult, it verifies itself over so wide a range that there can be little doubt that it is reliable. It turns out that the luminosity may be assigned when the mass and surface temperature alone are known. The other factors, the size,

the density—its distribution and its average—simply do not matter. This covers stars in such diverse states as the *Companion to Sirius* on the one hand, where the density is 30,000 times and the radius one-thirtieth of that of the Sun, and, on the other, *Betelgeuse*, where the density compared to the Sun is one-millionth only and the radius 300.

The low densities which are found at a small distance from an immense mass like the Sun must be still more pronounced in the loose bodies known as the gaseous nebulæ. Some of them, stretching over a large part of the sky, are wholly dark. The " rifts " that are seen in the continuity of the *Milky Way* are of this character. Possibly all are dark; at any rate we know that some at least owe their luminosity to stars embedded in them, which light them up like an incandescent lamp within a globe. But unlike such globes they show spectra of characteristic bright lines. In default of knowledge the element producing this spectrum was called " nebulium," until it became clear that there was no room for any element of that kind. At the date of writing, only two elements are undiscovered, but their properties can be predicted, and, among other things, they are heavy, whereas the matter in the nebulæ must certainly be light. Hence we have gradually become pretty sure that " nebulium " was merely a familiar element in an unfamiliar state; but only recently has its secret been disclosed. Among the great variety of changes between two orbits which are theoretically open to the electrons of most elements, are certain modes that are " forbidden," in the sense that the lines corresponding to them are not met with. The reason is that an electron, jumping to one of these orbits, remains in it perhaps a thousand times as long —so long, say, as a thousandth of a second—as it would in other orbits. Hence the absorption or emission that is related to it does not occur often enough to be seen. There are such lines possible in singly ionised nitrogen, and in singly and doubly ionised oxygen, and they have been shown to account for the mysterious " nebulium." Such a proof is not a conjecture. It follows the severest test of numerical agreement to five or six figures. One may ask why these " forbidden " states occur in the sky. The answer is that the matter in question is already ionised, and is so tenuous in density that the encounter of an " ion," that is a broken atom, with an electron or another ion, is in any case so rare that the " forbidden " states lose their peculiarity.

The " empty " space of the sky is nearly, but not quite, void of matter. Almost no general absorption takes place, which would be our ordinary test for the presence of matter there, even from remote stars, but these expanses have been found to contain enough atoms of ionised calcium and also of normal sodium to produce the characteristic absorption lines of such elements. At first these lines were attributed to the star by whose light they were seen, but whereas the other lines of the star showed the displacement of wave-length that is interpreted as motion, the calcium lines were steady. Their true origin as due to diffuse inter-stellar matter has been confirmed by measuring their intensity, which increases for remoter and remoter stars.

The presence of matter of such specific kinds in the depths of space presents the intriguing questions of how it got there, and whether there is anything else. As to the latter point, there is certainly something else

and something different from any matter or radiation that we encounter otherwise. There are the "cosmic rays," recently discovered and the nature of which is still mysterious. They come from the depths of space and are not related to the position of any of the most probable sources—the Sun, or the *Milky Way*, or the nearest great nebula in *Andromeda*. The Earth is bombarded by them wherever it goes. They have a penetrating power that much exceeds any other that we know, and would pierce some twelve feet of lead. Whether they consist of particles or ether waves has not yet been determined; nor what they mean, though so much energy can hardly result except from the merging of simple atoms into more complicated ones, or even the destruction of an atom altogether by the union of an electron and a proton, which seems to be theoretically possible.

That matter is destroyed in some such way, in the processes we witness in the sky, and energy given forth as radiation, can hardly now be considered a question of debate. Any other imagined method for maintaining the radiation of the Sun, for example, of whose duration in its present form we have some idea from geology, proves on examination to be hopelessly inadequate. Thus if we consider gravitational contraction, this would supply energy to correspond with current needs, but it would postulate a quite different Sun twenty million years ago; and other supplies are still feebler. The interior of a star, as we have described it a little way back, seems exactly the place where head-on encounters of electrons and protons may be met with, and we conceive that the result of such an encounter would be the disappearance of "matter" and the generation of a relatively enormous quantity of radiant energy. The Sun's radiation, though only a leak, is very great; in order to balance it, the Sun must lose matter at the rate of four million tons a second. But there seems no reason to call this quantity improbable. Even at this rate, its mass is so great that the supply would last twenty million million years.

GLOBULAR CLUSTERS

Leaving for the moment these matters which lie on the border-line between experience and speculation, let us proceed with the description of what is found in the skies. Next beyond individual stars come clusters of stars, and of these the most easy to characterise are the globular clusters.

The globular cluster in *Hercules* is the one best placed for northern observers, but if we describe one, apparently we describe all, for they are extraordinarily alike. Seen by the eye as a single star, the cluster in *Hercules* is resolved by the telescope into a multitude of very faint stars, scattered with a regularity, which is presumably merely an average from a large number of irregularities, over the whole field, and concentrating more and more densely to the centre. A good photograph shows much more. There are at least 50,000 stars in this cluster, and they concentrate so closely on the centre that they run over one another and become indistinguishable. About ninety of these clusters are known; they appear to be centred about a point in *Sagittarius*, in the *Milky Way*, and the Sun shows no sign of relation to their distribution.

This might have been all we know about them, if Cepheid variables (p. 130) had not been found in them. The Cepheid variables in these clusters are of extraordinarily short period—half a day or thereabouts. Now from the period of a Cepheid variable we can infer its real brightness, and if this is done, these apparently very faint stars turn out to be intrinsically highly luminous, so that their apparent faintness is no more than an effect of great distance. Comparing the apparent magnitudes with what we can infer of their real brightness, we can tell the distance that they are at. From such a calculation it appears that the cluster in *Hercules* is distant from us some 35,000 light-years. The nearest of the globular clusters, that in *Centaurus*, is 21,000 light-years. Most of them are much more remote.

In fact we require some more powerful method even than that of detecting variables, in order to get their scale of distance. Such methods have been found, depending on the great similarity between different clusters. The simplest is nothing but a comparison of the apparent diameters. Another depends upon the brightest stars in the cluster. Trusting to these, one cluster has been found to lie ten times as far away as the cluster in *Centaurus*.

It is unnecessary to spend words in attempting to make these figures more impressive. They are measures, not vague surmises. They may be disturbed in detail, perhaps, but not in scale. They extend our knowledge in a way that prepares for further extensions. They represent something, obviously systematic and utterly beyond what we could measure, or could hope to measure, using as scale the ordinary "astronomical unit," or distance from the Earth to the Sun—ninety-three million miles. They ignore the Sun in their arrangement, and point to another centre.

We may record a few further details. Their motions are large, both relative to one another and relative to the Sun. Each cluster separately may extend to a diameter of about 100 light-years. The star density at the centre is about 1,000 times as great as it is near to us. In spite of this, the stars that compose them are presumably at great distances from one another. It must be remembered that even if our neighbours were tenfold nearer, which would increase the density a thousandfold, they would still be very remote. The greatest stars within the clusters are red supergiants with diameters two or three hundred times that of the Sun, like *Antares* and *Betelgeuse*.

THE SPIRAL NEBULÆ

Next in order of hierarchy beyond the system of globular clusters are the nebulæ. There are nebulæ which seem to belong to the *Galaxy*, and others styled extra-galactic nebulæ. We shall treat the former very briefly. Although few in number, they are remarkable, most because they are gaseous. What their spectra show has already been dealt with (p. 140). They are apparently envelopes, consisting of light atoms, ionised and in a state of great tenuity, surrounding some star from which they receive radiation, to emit it again with a stamp of their own. They are of great dimensions, probably exceeding many times the whole solar system. So far they have not been connected rationally with any other formation.

Quite other are the extra-galactic, or spiral, nebulæ. For one thing, the spirals are both enormously greater and enormously more numerous, so that it is a moot question whether they are not the generating points from which the whole celestial panorama unfolds. They are also, as will appear, enormously more remote. Without being moulded exactly upon one pattern, they present unmistakable signs of a common chain of development and vary from one another by their stage of advancement, and by circumstances one calls accidental.

The name " spiral " is derived from the form assumed. If we imagine a tracing point to go round and round the origin from which it started, but to get continually further away, it will trace out what geometers call a spiral. Such forms are shown with the utmost clearness in some of the spiral nebulæ, only in place of one spiral we have two, starting from the same origin, interlocked and just opposite to each other.

The most prominent, and presumably the nearest of the spirals is the great nebula in *Andromeda*. On a photograph, a record can be obtained, stretching across fully a degree of the sky, that is, twice the diameter of the Moon, though the eye sees only the condensed centre as a hazy star. It appears as oval in form, with fissures that might mark a succession of rings, but if we take the other spirals to interpret it, we see that we are viewing in perspective a flattish object, lying near to one plane, with a central nucleus from which two long arms extend round and round it in what are spirals pretty close to the type called " equiangular."

Learning from other spirals, we see that the nucleus lies equally above and below a certain plane of symmetry ; it may be round or oval shaped or flattened ; in the last case it is frequently, and apparently characteristically, obscured along its central plane of symmetry by a dark band, which has been interpreted as an escape of matter from it, cooled by the escape. The arms, or spiral prolongations, from the nucleus lie also in this plane of symmetry ; they may be more or less extended and regular, or not at all. They are punctuated throughout their length by condensations, which are stars.

The nucleus is much brighter than the arms. In the *Andromeda* nebula it is impossible to secure a photograph of the extensions without greatly over-exposing the central part. And in most of the photographs the image has a " woolly " look that strongly suggests an incandescent gas, with a soft boundary. Yet it is uncertain whether the spirals are truly gaseous at all. Their spectra are continuous, generally of the solar type. And high telescopic power separates at any rate some parts of them into distinct stars which run into one, as the *Milky Way* does, under a lower power. These may be plunged in nebulous matter, which they illuminate. The spirals range downwards in apparent size, from the *Andromeda* nebula, which is the greatest, because, as one supposes, it is the nearest, through a number of other striking examples, until we come to a host of small patches of light that it is just possible to recognise as belonging to the family. Their number is enormous. Probably the telescopes at present in use could record half a million. And each of them that we can examine in detail envelops a countless host of separate stars.

There seems no room for systems on this scale, within any other system than their own. And indeed they hardly seem to belong either to

us or to one another. An estimate has been formed of the distance of the nearest—that in *Andromeda*—following the method that proved so reliable for the globular clusters. Some minute stars, of the eighteenth magnitude, which means an exceedingly faint star, were recognised as Cepheid variables. Their period gave their actual brightness, namely 5,000 to 10,000 times brighter than the Sun, from which a calculation shows that this nearest of the spirals is nearly a million light-years away. Indeed there is some reason for saying that the spirals are on the confines of space, if we are to suppose that space has any limits. For their velocity towards or away from us can be determined in a number of cases, and after removing an enormous motion relative to the Sun, with one accord they show a still greater velocity of recession, or departure, from one another. No one has suggested a reason why they should spread out in this way, so that one is disposed to accept the interpretation which General Relativity would put upon it—namely that it is not an actual recession at all; but if space is supposed to be finite and re-entrant on itself, like a kind of sphere, a very remote object in that case would show a spectrum in which the lines were not of the wave-lengths we expect them but were all displaced so that all the wave-lengths would seem bigger. We are used to such displacements, and our regular interpretation is that the object is going away from us. But it may be that the spiral nebulæ are merely informing us that they are so remote that space itself has suffered a change.

THE GALAXY

The description of these lesser and greater orderings among the stars leads up naturally to the question—What is the *Milky Way*? Even the unaided eye shows it to be a central feature, and a proof that a system of some large kind exists. More careful work, as by star counts, and the distribution with respect to it of characteristic objects, confirm the fact. Still it has proved extremely difficult to assign a position to it, in any general order. If we give here with some confidence the views that appear to be prevailing, they must be read as not yet wholly established. They are, on the whole, greatly more enlarged than would have been acceptable a few years back. If this implies trusting to some perhaps uncertain ground, it must be remembered that all the indications point in the same direction, and that again and again, from the earliest times when Aristarchus made the Sun only five times the diameter of the Earth, astronomers have been forced to expand their conceptions, on a better knowledge of the facts. Perhaps this note of caution may convey too much doubt to those not used to the methods of astronomers. All that is given summarily below is the view of students of the problem of many years' standing, who are almost as good judges of a forecast as of a proof, and moreover much that it contains has been proved up to the hilt.

The *Milky Way* presents large ill-defined features which do not offer any easy clue. It is very different in brightness in different parts. One decided condensation has the dignity of a constellation—*Scutum Sobieski*; the brightest part is in *Sagittarius*; for a great part of its circuit round the sky, it is split in two by an immense dark lane. The stars into

which Galileo confidently and correctly resolved it prove, upon scrutiny, to be excessively small, so small as to reach the limit of separate detection with our present telescopes.

There are more and more of both visual and telescopic stars as we approach the *Milky Way*. On closer scrutiny, too, the condensation of stars towards the *Milky Way* proves to be only the beginning of the story. If we suppose that this greater number comes from looking into a greater depth, we conclude that it means that the stars around us are spread out in a sort of disc, with the Sun near its centre, or on the whole a little to the north of its central plane. Call this disc-like extension the "local cluster," or as it is sometimes named "the Kapteyn universe." We find that the clustering does not extend beyond a distance we can put roughly at 1,000 light-years, after which we have nothing like reached the main *Galaxy*. Moreover the central planes of the local cluster and the *Galaxy* do not agree. The local cluster is inclined at about 12°, which is more than one-eighth of a right angle, to what is estimated as the equator of the *Galaxy*.

In these circumstances one must look elsewhere than to the local cluster, large as it is, for a parallel, and the *Greater* and *Lesser Clouds of Magellan* naturally invite examination. Fine photographs of these grow more and more impressive the more one knows. The "clouds" themselves are well defined patches upon rather blank parts of the sky, made up of countless systems of individual stars, groups, clusters, and spiral nebulæ. Recalling what great organisms the spiral nebulæ are, it is no wonder the *Clouds of Magellan* have been called "Island Universes." Since Cepheid variables have been found among their members, the extraordinarily fertile method of the period-luminosity relation, which has been referred to already in connection with the distances of the globular clusters and the *Andromeda* nebula, has told the actual distances of these clouds. We find in consequence that the faint stars that are apparently of thirteenth magnitude are in reality super-giants that, at ten times the distance of *Sirius*, would exceed it in brightness. The enormous distances of 112,000 light-years and 110,000 light-years have been assigned to the two clouds, with diameters 14,000 and 7,000 light-years respectively. They are separated by 40,000 light-years from one another and are widely separated from the plane of the *Galaxy*.

Yet great as these systems are, consideration of these figures shows, as has been said, that if they are island universes the *Galaxy* itself is a continent. No direct measure of its span has been found, but indirectly the globular clusters, which are associated with it by symmetry, give a clue both to its size and its centre. The centre of the system of globular clusters is in *Sagittarius*, where the *Galaxy* is brightest, and where there is an immense condensation of stars, the brightest part apparently hidden from us by one of those dark patches that make the "lanes" and are associated with the local cluster. Now the distances of the globular clusters were among the first fruits of the method of Cepheid periods. And several pairs of these clusters are separated from one another by a quarter of a million light-years and upwards. Hence we shall have the right scale of ideas in thinking of the *Galaxy* as 300,000 light-years in diameter. If we want something to compare with this, we must look elsewhere than in the

Andromeda nebula or the *Clouds of Magellan*. We must search for super-systems, very remote of course, and including within their borders a multitude of great systems reduced to faintness by distance.

Such super-systems have been found and, what is more, the energy and thoroughness of Shapley, who first determined the distances of the globular clusters, and who is still at work upon the problem, have searched, to demonstration, what they contain. We can give some idea of the grounds. For example there is a somewhat insignificant patch of a few square degrees on the sky, crossing the constellations *Coma* and *Virgo*, which shows on a photograph of long exposure a large number of faint spirals. The actual number brought under examination is over 2,700. Their condensation in groups, their apparent diameters and other features have been examined, and in particular the distance that must be assigned to the collection. No variables are available for this purpose. The distance is estimated by comparing the appearances presented in the system with those of the *Andromeda* nebula and other systems for which, being less remote, the argument from observed variables is offered. The estimation is a matter of delicate judgment, but for our purposes not less reliable for that reason. The diameter arrived at for the super-system is two million light-years. The distances of the separate clouds differ widely, from eleven million to 150 million light-years.

It is evident then that we must treat this insignificant patch of faint objects as a super-system comparable with our own *Galaxy* and indeed exceeding it. Others have been found which are even greater and more remote, and the discovery for the present is terminated, not by want of material, but by the feebleness of our telescopes. But it is sufficient. We might get more detail, but we should not vary the view, which really answers the question with which this section began—What is the *Milky Way*? We must regard it, not as one system, but as a group of star clouds, which are collected in a flattened form, neighbouring and presumably influencing one another, though at immense distances, and each one of which might be called a universe. Our own local cluster, the " Kapteyn Universe," may be a degenerate spiral, to which in size it appears to belong. The nebulous appearances of these spirals seem to be only a result of the great distances at which they are seen. In that case, the dark nebulosity that hides so much of our sky would be interpreted as one of the dark bands that appear along the central planes of many of the spirals.

If this is the correct point of view, our local system is nowhere near the centre of the great *Galaxy* of which it forms an element, rather it is near the rim. All considerations point to a centre near the star cloud in *Sagittarius*, distant from us by say, 100 million light-years. And any apparent motion in the other parts, so far as it can be brought under one head, should more properly be attributed to our own system, than to the greater system with which it is compared. From this point of view the so-called rotation of the *Milky Way* should be regarded. Difficult as it is to treat, very definite and consistent results have been obtained, and these show that the local system and the great *Galaxy* are in rotation relative to one another and would turn completely round in a period of the order of 100 million years.

Under the imposing name of Cosmogony we consider *How Things Came To Be*. Really this is no part of an astronomer's obligation, but possessing curiosity like other people, he is interested in it. Yet before saying what can be said about it, one should in fairness indicate how large a proportion is of necessity inference. To describe the evolution of an organism is synonymous with giving its history. This can be done with some certainty in such limited fields, for example, as the meanings attached to a word in the language, let us say the word *post* or *humour*. But it is a very different matter to give the history of a natural object. Even in a case where the evidences are abundant, as for the human skull, often the best that can be said of a theory that connects them is, that it cannot be disproved. In astronomical matters we are on even weaker ground. The periods of time that must be considered are so vast, that in a quite literal sense we know only one point of the history and must infer the whole past and future. It is true that in many regions there are a great many examples which we assume to show different stages in a common succession, as we can infer the course of human life from the infant, the boy and the man, without watching the one develop into the other. But experience in the regions of Natural History, with its missing types and conflicting remains, does not encourage optimism or even confidence.

Yet, speaking first of the Solar System, some common connection is evident; in fact, if put in mathematical form as an estimate of probability, the evidence is overwhelming. The greater planets and nearly all of the host of minor planets move round the Sun, near to one and the same plane and in the same direction. There is no process in operation to make them do so, for the comets, which are also members of the solar system, do not. We may reserve the discrepancies shown by the new planet *Pluto*, until we know more about it. The alternative to plan is chance, but it is easy to see that the probability against such a coincidence by mere chance is overwhelming. How then did this evident system originate? Up to quite recent times the usual answer was contained in Laplace's Nebular Hypothesis, of which Poincaré said in the nineties that, considering its age, it didn't show too many wrinkles; though a little later Sir James Jeans remarked that the difficulty of disproving it was the same as that of proving anything definite about it—an ominous dictum for a cosmologist. This hypothesis supposed that both Sun and planets were formed out of a single original gaseous nebula, contracting on itself, rotating faster, as it would, and flattening out in the process. The planets were formed out of rings shed off in succession and collected into single bodies, while the Sun was the residue that remained at the centre. Under cross-examination, the answers of this theory to such questions as why do the planets rotate in the same direction as they revolve round the Sun are so unsatisfactory that as a theory it has been abandoned. It may perhaps apply elsewhere, but not to the solar system. But it has been no easy matter to find an alternative. Indeed there is only one that is current to-day, and that depends upon an *If*.

In place of imagining the planets to have been formed in a process of contraction which finally left the Sun in the middle, the Sun is imagined

as formed first without planets. It would have remained without planets great or small unless it had experienced, once in its history, some great cataclysmic disturbance. The nature of this disturbance is supposed to have been tidal. All tides have the same character, which can be readily understood. An external body, like the Moon, attracts the Earth. The first effect is shown in a revolution of the centre of gravity of the Earth about the common centre of gravity of the Earth and Moon. But there is a secondary effect which shows itself in an elastic deformation of the solid earth and its atmospheric and aqueous envelopes into elliptical shapes, which follow generally the position of the Moon. The last of these, which gives the tides in the ocean, is familiar, but the others have been verified too. In the case of a more labile body than the Earth, and a greater disturbing body than the Moon, the tides might rise to any height. They might form an immense jet directed generally towards the disturbing body, which ended by breaking into drops, which never fell back upon the parent Sun at all, but had sufficient motion conferred upon them by the disturber, before it passed, to ensure their revolution in orbits. This is the tidal theory of the genesis of the solar system. It would explain how the planets all were near one plane, which the Ancients knew and designated by the Zodiac; it would explain why they all go round the same way, and, if we suppose the disturber to have passed near by in the direction in which the Sun was rotating, it explains also the agreement of the Sun's rotation with the revolution of the planets. Things which it leaves to be cleared up are the near approach of the planetary orbits to circles, and the exceptional but definite presence of satellites which are *not* circulating in that way. But the difficulties of finding any explanation are so great that one is inclined to hope that a way out will be found. It may reasonably be said that we cannot expect a theory to explain every detail.

The disturbing body must of course be imagined as a star, and here arises the great difficulty of the theory. For tidal effect, proximity is more important than mass. The Sun produces on the Earth only half as great tides as does the Moon, though it is twenty million times as massive—because it is four hundred times as far away. The passing star would have to make its closest approach to the Sun at much less than the Earth's distance. Now the first fact about the stars is their isolation. It is of course not impossible that in the remote past a star passed near the Sun. The chance that one might do so can be estimated. The result is unfavourable. Unless a perfectly immense period of time is allowed, the chance against the approach of a star sufficiently near to bring the planetary system into being is as overwhelming as is the evidence that the system did not originate by chance. This does not quite demolish the theory. The latest views are inclined to leave open immense lapses of time, in which things may have happened, and there is always the chance that an off-chance comes off. But it is not convincing. It may be that this theory does not need very much adjustment. Theory shows that the normal development of a rotating star leads to fission. A body originally spheroidal develops into an elongated ellipsoid, then into a pear shape, then into a shape like an unequal dumbbell or gourd, and finally breaks into two parts which recede from one another. This break could hardly be a clean one, and would result in the formation of a not very regular set of drops that would

be endowed with orbital motion. Some of them would form planets round the one star and some round the other. This would abolish any question of the genesis of our system as the consequence of a very improbable coincidence. Incidentally it would make a planetary system the possession of a great many suns.

As there are so few tenable theories of cosmogony, we may glance again at the nebular hypothesis, in a connection where at any rate it has not been disproved. It seems, in many respects, to fit in with the history of spiral nebulæ. Laplace imagined a primitive nebula which was gaseous. It is very doubtful if the great spiral nebulæ are gaseous. They do not show the spectrum of a gas, and under high resolving power their gaseous appearance shows signs of breaking up into stellar points. But if we suppose them to be collections of rotating gas, it can be shown mathematically that we should have a sequence of states which appear to be illustrated in the sky—nearly spherical forms, becoming elongated ellipsoids under greater condensation with its more rapid rotation, then breaking out along the equator with streams of escaping, and presumably cooling, and therefore dark, gas. These dark equatorial bands appear to be characteristic of the course of development. Indeed it is conjectured that the " dark nebulæ " that obscure so much of our own sky, and are associated with the local cluster, are of that kind. This would make our " local cluster " nothing but the stars into which a parent nebula has broken.

It is true that spiral nebulæ develop in two great whorls of stars, arranged in a geometrical shape, and we are at a loss to assign any reason why this should be a regular event in the history of a rotating gas, such as Laplace imagined. But a great many features fit, and we may end, not by rejecting Laplace's Nebular Hypothesis, but by promoting it to an application far vaster than he dreamed.

One word may be said in conclusion. Every astronomer has had occasion to learn that people are more interested in the origin of life than in that of the planets upon which it may be supposed to exist, or the stars of which these may be the offspring. He may be excused for waving such questions aside. It is not his affair. Our life exists under very narrow limitations, which hardly touch astronomy. The astronomer cannot point to any other place in the universe where life, as we know it, could be supported. In short, anyone can judge the question as well as he.

PROGRESS AND DECAY

The use of these popular words to summarise the present section is deliberate. But before science can say anything about them, we must first strip them of the moral attributions that lend them nearly all their attraction. If this is done, we recognise in nature two kinds of process, *prima facie* fundamentally different, and must enquire what is the real distinction between them. The first process goes on, so far as appears, without change of type, for ever. There are innumerable examples, of which we need only mention, on the large scale, the motion of the Earth round the Sun, and on the small one, that of an electron round its nucleus in an atom. The second kind progresses towards some ultimate state. Again the examples are so easy to find, that this process was thought of,

up till yesterday, as a summary of Nature. The diffusion of motion, the diffusion of heat, the degradation of energy are commonplaces to everybody. If asked what was the purpose of life, you could answer in one word, —death. But science has nothing to do with grim or emotional colouring—what we wish to determine is, whether there are indeed two kinds of process, or only one—whether we can assign an end towards which things travel, or whether they continue in changing figures of one endless dance for ever.

One alternative, which will suit some of the cases, is to suppose that the things that go on for ever are really an ultimate state in which the element of change has exhausted itself. Consider, for example, the system of the Earth and Moon. The Moon's rotation occupies the same time as its revolution round the Earth. It can be shown that this would follow from tides which the Earth would raise upon a Moon when the latter was in a plastic state. And in the same way the friction brake which the tides apply to the Earth's body will infallibly slow the day down till first it is equal to the month and ultimately to the year, producing at the same time other changes in the orbits, until finally all sleeps in one unending night —*nox est perpetua una dormienda*. But though that might do for the Earth and the Moon such a history would not fit the atom at all. As far as we know, the quantised states, as those states of the atom are called which operate by the gain or loss of a quantum, shift back and forth without a trace of decay.

One may think, on the other hand, of the uncompensated outflow of radiation from a star. Briefly the current description is this:—intense relative motions within the star convert its matter into radiative energy, which soon or late escapes from the surface and travels away through space for ever, producing almost infinitesimal mechanical or thermal effect that might possibly return. Even here we must be cautious. We have learnt that while the "temperature of space," *i.e* the temperature of any absorbing matter there may be, which results from such radiation, is a few degrees only above absolute zero, the conclusion is profoundly modified if atoms are met with that are capable of *selective* absorption; the resulting "temperature" of such an atom may be far higher than that of the emitting body. Still we can hardly say that this modifies our view by much. The four million tons of its mass a second which the Sun converts from matter to energy, and pours out as radiation, is gone for ever and will not be replaced in any shape or form. We have to accept as typical of at least one side of our system a process which goes on in one direction only and cannot be reversed, and which leads as a limit to a state in which no further exchanges are possible.

This is the well-known doctrine of the degradation of energy, which was more readily received before modern physics established itself. Modern physics has disestablished so many accepted ideas in the course of establishing itself that it becomes necessary to re-examine the idea of the degradation of energy. Regarding heat as nothing but irregular motion of the molecules, it becomes essentially a question of the diffusion of motion. Now if anything is diffused or distributed, let us say by chance, the state which we are most likely to find is the state that contains the greatest number of equally probable arrangements. Suppose then we

start with an unequal distribution, such as one end of a bar hot and the other cold, this might be called as probable as any other distribution, and so we might expect to find it at any subsequent time. But we do not. On the contrary we are sure to find that the temperature has equalised itself throughout the bar. Now it may be said that an exactly equal temperature throughout the bar is just as improbable as the state from which we started. That may be. But the cases that would *pass* for equal, by any tests we can put, are so enormously more numerous than any other state, that practically we find nothing else. Modern physics says nothing to rebut this argument. Therefore it remains; and it is a typical case of the degradation of energy.

Be it remarked that we invoke in this discussion nothing but " chance "; it implies no intelligent guidance. Maxwell imagined a method of reversal of the " second law of thermodynamics," which is just a statement of the continual degradation of energy; he imagined " demons " watching the separate molecules, and separating those that were moving fast from those that were moving slowly by opening trap doors to let them pass. The result would be the same as arranging that a bar should, of its own action, make one end hot and the other cold. But these demons must have been intelligent. The task of physical science is to show what follows in Nature, apart from intelligent guiding.

But what is the source of the tendency, always working in one direction, that gives us first hot concentrations of matter like the stars—depositories of stores of energy that thereupon dissipate themselves as rapidly and completely as the circumstances allow? It is simply the unidirectional character of gravitation, which collects all matter into a centre, unless it is endowed with sufficient lateral motion to ensure the description of an orbit. At the centre, exchanges of motion take place by collision, and we have the concentration of heat and ultimately its diffusion. In the atom we have both positive and negative electricity, with attractions and equal repulsions. But in gravitating masses we have attractions alone. Necessarily so, for if we suppose that any stuffs that repel one another exist, they would mutually drive one another away until the field contained one kind alone. Say we are left with that kind of attracting stuff, and call it matter, then the familiar degradation of energy, with its terminus i what is known as a " heat death "—though not a death of motion, as fi as motion persists in orbits—becomes inevitable.

In somewhat the same way as the Moon's orbit remains after all its heat-motion is radiated away, while it is now believed that a star is continually transforming its mass and dispersing it as radiant energy, there will remain from this process an inconvertible residue of dead matter such as we see in the Moon, for which there is no more prospect of further conversion than there is for a conversion of a residue of orbital motion. Unless again this dead residue, whether matter or orbital motion, is ultimately dissipated by bombardment by cosmic rays.

THE TIME SCALE

We touch the universe at a single point of time. Apart from memory there is no such thing as a past. Even if we include memory and supplement it by records that can be called scientific, the time is so brief in

which anything definite has been known of the heavens that we hardly need to modify the above exact statement. An astronomer, therefore, might decline to speak about what is not before his eyes. And there is the further complication—that must not be treated as of no practical importance in relation to the universe—that simultaneity and the time sequence possess no common meaning for different minds. If we speak of the history of things, it is evident that we must do so in a conventional way. We are divorced from direct observation of the history of any individual object, and must rely upon recognising, among the diverse objects presented to us, specimens of successive stages through which the individual has passed. He may make a mistake in doing so. The manner, the order, even the members that are selected by his theory, will depend upon the theory he adopts. The ground, therefore, is uncertain. But the astronomer is in no worse case than any other naturalist, and better placed than many. In any case, with the proviso that the picture is conventional, theoretical, and must not be taken too seriously, it will aid the comprehension of what has been written if we add here some account of how long the order of things we see has taken to come about and how long it may be expected to endure. The account will be very brief, for the agreement among astronomers, such as it is, is rather rough.

The age of the Earth is about two thousand million years. In making the statement we recognise that it rests upon an element of observation and an element of theory. It is an inference, and its reliability depends less upon the question of making the observation correctly—for this may be revised and refined—than upon being able to say that the theoretical process has continued at an unchanged rate through that great lapse of time of which we have no experience. It is evident that this objection will envelope in doubt any such measure of the Earth's age as the rate at which the salinity of the sea increases. Much more satisfactory is the rate of degradation of radio-active materials. Radio-activity is an atomic process which neither heat nor pressure nor any other force that we know can either hasten or retard. In this way, uranium degenerates into lead. The physicist can distinguish the lead which resulted from the break-up of uranium from other lead that is indistinguishable from it by chemical tests. In certain rocks, uranium and its degenerate lead are found, and if we assume that the process has gone on at the same rate since the crust of the Earth was first formed, we arrive at an age of one or two thousand million years. Other indications confirm the figure. Strictly it refers only to the formation of the crust, but if the genesis of the planets that has been exposed in an earlier section is accepted, the Earth must first have existed as a glowing liquid drop of the Sun's body. But when direct communication of heat to this drop was broken, and it lay open to radiation into cold space, it seems reasonable to conclude that a crust of rock would be formed in a time that was a negligible addition to the age that has been mentioned.

It would follow that the other planets have the same age. We have no means of estimating directly, but it is probably significant to point out that small bodies like the Moon and *Mars* seem to have had less power to conserve their original state than the Earth, while great ones like *Jupiter* and *Saturn* have degenerated less.

The age of the Sun must be estimated with the same cautions in mind. We must have an observation of the present rate of some process, and an adequate theory by which we can go back into the remote past until we arrive at a state that can be called primitive. The most satisfactory theory is that which connects the mass and luminosity of a star. Derived originally as pure theory, it has proved to apply closely to the luminosity of all stars of known mass. We have therefore only to fit it on to the present mass and the present luminosity of the Sun, and we obtain with some confidence a picture of the latter's previous history. If we do so, we find that at the time when the planets came into being, the Sun was much as it is now, but if we go back to a million million years and beyond, it becomes a different story. Radiation diminishes the mass, and the theory shows that a greater mass gives greater and continually greater radiation. From the greatest stars there is a torrent of radiation that reduces their mass at headlong speed. Before we reach backwards to eight million million years, the Sun would have had a mass equal to that of the greatest star known.

Having gone so far in theory, it is tempting to go further. But we must recognise that the ground becomes more and more questionable. We have before us stars in various states of development. Consider a giant star such as *Betelgeuse*—the Sun may have passed through a similar state, but what was *Betelgeuse* itself at that remote period? We cannot point to any object known as an answer. At least it seems certain that the stars did not all come into existence simultaneously, as we suppose the planets to have done.

More precarious still is anything we can say of the past history of still greater organisms such as the spiral nebulæ, and in an outline such as the present, where the attempt has been made to show the grounds of confidence as well as to state the articles of an astronomer's belief, we may fitly refrain from pursuing the speculation.

A work that is too well written to be called out of date is

SIR A. S. EDDINGTON : *Stellar Movements and the Structure of the Universe* (London. 1914)

For those who are interested in the history of the subject we may mention

A. M. CLERKE : *History of Astronomy in the Nineteenth Century* ; 3rd edn. (London. 1898)

G. FORBES : *History of Astronomy* (London. 1909)

and for details of the lives and theories of earlier astronomers

J. L. E. DREYER : *Planetary Theories from Thales to Kepler* (Cambridge. 1906), and

A. BERRY : *A Short History of Astronomy* (London. 1898)

THE NATURE OF MATHEMATICS

By

JAMES RICE

SYNOPSIS

Introduction : Mathematics and the practical needs of Man — Mathematics as distinct from the arts of calculation and mensuration — The contributions of the Egyptian, the Greek, the Hindu and the Arab.

Number : The laws of numerical operations — The Commutative. Associative and Distributive laws as applied to numbers — The use of the plus and minus signs and of brackets — Algebraic symbolism — Integral numbers — Fractional numbers and Decimals — Irrational numbers — Positive and negative numbers — The generalisation of the meaning of number related at every step to the practical activities of Man.

Algebra : Problems and algebraic symbolism — Formulæ — The fundamental laws of algebraic operations — Factorisation of algebraic expressions — Algebraic symbolism is no mere " shorthand " — Logical and mathematical principles — Equations — The origin of the name " Algebra " — Methods of solving a quadratic equation and the duality of the roots — Equations and practical problems — Imaginary numbers — Generalisation of the idea of a " power " of a number — Algebra beginning as generalised arithmetic becomes a weapon for dealing powerfully with the variable quantities of natural phenomena — Functionality.

Geometry : Extension of bodies in space — Surfaces, lines and points as abstractions from the real properties of bodies — Geometry concerned with such abstractions — Euclid's great treatise : a brief summary of its contents — Axiom and Postulate — Construction and Proof — The famous Euclidean postulate as to parallel lines — The dependence of his conclusions on the truth of this postulate — Digression on the actual experimentally observed facts of our physical space.

Limits, The Calculus, Periodicity : The notion of a limit as suggested by observation on moving bodies — The world as a flux of events and not as a static configuration — Differentiation : its importance for the laws of Physics — The notion of length as applied to a curve — Integration — Convergent and Divergent Series — Trigonometry and Periodic Functions.

THE NATURE OF MATHEMATICS

INTRODUCTION

The study of the sciences originated in the practical needs of men, and Mathematics, though the most abstract of the sciences, offers no exception to this statement. We can see the beginnings of arithmetical calculation in the primitive requirements of the race, when men bartered articles with one another or divided their prey into portions, and perforce had to be able to count so as to maintain a rough justice in their division or exchange. In more settled conditions, when the tilling of fields became the vital activity of a tribe instead of hunting, the necessity of dividing the cultivated area into suitable portions for each family of the tribe compelled them to develop some elementary notions of mensuration. Nowadays, when the word "mathematics" is mentioned, the first idea to arise in the mind of the average man or woman in this connection is linked with the art of arithmetical calculation or skill in solving geometrical problems. It is true that education in our schools is developing so far that the subject of algebra probably presents itself to the hearer's mind as well as trigonometry and calculus. But to the average boy and girl with a good secondary education algebra is still "generalised arithmetic," in which the calculations are carried out with letters instead of "real numbers"; trigonometry is a kind of mixture of algebra or arithmetic and geometry; and calculus is a peculiar pursuit that "looks like" algebra, but differs in one strange operation which can be technically mastered with sufficient practice and assiduity, but still remains somewhat of a mystery both as regards its reason and its purpose. Hence, despite all our sophistication, "mathematics" as a name conjures up notions which are clearly related to "arts," rather than "sciences," the cultivation of which was one of the prime needs of man the moment any form of communal life, based either on food-getting or food-producing, came into existence.

We have no record indeed of those early geniuses of our race who first recognised the difference between "one," "two" and "many," who then proceeded to subdivide the "many" into "three," "five," "ten" and so on, and who realised that the number of fingers on one hand or on two and the number of toes on the feet were an extremely convenient piece of machinery for help in counting; or who gathered flints or pebbles and laid them down, one by one, to indicate to their fellows the number they wished to convey and then, recognising the clumsiness of these methods of communication, invented sounds and signs to convey to the hearer the idea of the number in question at the moment. But after all, mere counting lacks the special character which makes arithmetic one of the mathematical sciences and the most fundamental of them. It is hard for us to realise the immense stride in human thought which carried us from counting to the study of "number" in itself as an object of

interest, when we began to realise that six pebbles, six arrows, six men, six trees had something in common which is neither pebble, nor arrow, nor man, nor tree, that something being just " six " itself; when it dawned on the human mind that numbers had an interest of their own apart from *numbered objects* and presented a uniformity of behaviour in all circumstances of counting which is the very characteristic of all facts capable of being scientifically summarised. That six sheep and four sheep made a collection of ten sheep, that six pebbles and four pebbles made a heap of ten pebbles, in fact that six and four *always* " made ten " no matter what objects were involved, was a scientific generalisation which must have cost some primitive Newton much mental travail and earned him the admiration and reverence of his less gifted fellows. We may presume that he was a priest or medicine man. When we come to the civilisation of the Egyptians and the Babylonians, the records show that such purely intellectual pursuits were the special province of the priestly caste. But even in these great states, with all their wealth, refinement and pomp, the real nature of mathematical knowledge was not discerned. This statement can be brought home to the reader by a simple illustration. Mensuration was a necessary art for the Egyptians. The rise of the Nile annually wiped out all the landmarks which divided field from field in the arable land which fringed its banks. When the river receded, fresh division of the soil had to be undertaken among the various tribes, and so a considerable body of mensurational propositions became known in an empirical way, *e.g.* how to find the area of a triangle. But to the Egyptians this was all " earth measuring." Apparently the desire to know something about form and figure, apart from particular fields and *as something distinct from any material thing*, never arose in their hearts. It was the Greek who first made that great flight of spirit, although he modestly kept the Egyptian name " geometry," which means literally " measurement of the earth," for a mental discipline which is as unlike the Egyptian prototype as a symphony is to a folk-tune. Again, the Egyptians had their skilful builders of pyramids and temples, and one of their stock-in-trade implements was a rope divided by knots into twelve equal lengths. With this they could make a triangle of sides 3, 4 and 5 units, and they knew that between the short sides there was included a right angle. But it was a Greek, and not an Egyptian, who thought about right angled triangles in themselves apart from strings, ropes and special sizes, and discovered the great proposition about the square on the hypotenuse being equal to the sum of the squares on the short sides. The average man probably does not realise that this proposition, the discovery of the famous Pythagoras, enters decisively into all our ideas about the nature of physical space and, with its modern extensions, forms the starting-point for introducing any method of measurement at all into that child of modern thought, the space-time of the relativist.

The love of knowledge for its own sake amounted to a passion with the Greeks in the golden age of their history, and so it is but natural to find the early developments of Mathematics in the proper sense of the word as one of the manifestations of their genius. To them number was an absorbing topic quite apart from skill in calculation or the special properties of numbered articles; and the general laws of form and figure exercised

their intellect quite apart from the material bodies which presented to them the infinite variety of shapes with which we are familiar in daily life.

The word " Mathematics " is found in Greek literature at the time of Plato, but not specialised to the meaning it acquired later. With that great philosopher *mathema* (literally " a thing learnt ") means any subject of instruction or study. Yet he does say in the *Laws* that three subjects are specially fit for free-born men ; they are arithmetic, the science of measurement (meaning what we now call geometry), and astronomy. His emphasis on these three subjects gradually led to a specialisation of the word *mathema* to these and similar objects of study, so that in the time of Aristotle the convention had so far hardened, that his followers explained the particular use of the word by pointing out that subjects such as rhetoric, poetry, music or literature could be understood even by one who has not learnt them, but that the subjects grouped by them under the name *mathemata* could not be known by anyone unless he had received a definite course of instruction in them. The word *mathematike* appears to have first come into use in the time of Pythagoras a century and more before Plato, and seems actually to have had, with the Pythagoreans, some of the specialised meaning definitely assigned to it by common consent later ; be that as it may, by the time of Aristotle the term *mathematics*, meaning literally " things fit to be learnt," had definitely established itself as referring to the subjects such as arithmetic, geometry, astronomy, optics, etc., which were regarded as above all others the things in which it was most suitable for a cultured man to receive instruction.

So clear were the minds of the Greek thinkers on these matters, that they used entirely different words to distinguish between these lofty mental exercises and those mere arts and practices of daily life and business which had some connection with them. Thus Plato uses the word " arithmetic " to mean what is commonly meant by it to-day in any school curriculum, but a different word " logistic " to denote the art of calculation. Thus he would have referred to " lightning calculators," and those who can tot up columns of figures with speed and accuracy, as men who are " logistic " by nature, but he would not have called them " arithmeticians " unless they had shown themselves capable of studying and grasping the true theory of number, as distinct from calculation. He did not despise *logistic*, for he admitted that naturally slow people would be made smarter by it and that it was a very necessary accomplishment in daily life ; but he would have regarded the acquisition of the art of calculation only as a preparation for the study of the true science. Similarly in the time of Aristotle, a clear distinction was drawn between " geometry " and " geodesy," the former being geometry in our sense (though showing its origin in its name, " earth measurement "), the latter being what we should call " mensuration," meaning not only land-surveying but all practical measurements of length, surface and volume. Aristotle seems to have been the first to indicate a division in Mathematics which is acknowledged in school and university curricula to this day, namely, the separation of the general science into two branches, " Pure " and " Applied." Thus he refers to Mechanics, Optics, Harmonics and Astronomy as the more physical branches of mathematics,

pointing out that the proof of propositions in these subjects depends on the pure mathematical subjects, Geometry and Arithmetic.

Although we derive our names for Arithmetic and Geometry from the Greeks, we must not forget that the Hindus independently cultivated these subjects, and it is from the Hindus that we derive our present numerical notation. The forms 1, 2, 3, etc., for the numbers are our copies of a variety of symbols used by the Hindus in their writings, and have in modern times replaced both the Greek method of using the letters of their alphabet for this purpose and the clumsy Roman numerals I, II, III, IV, etc.

So far we have not mentioned Algebra, the third of the trio of subjects whose names leap to the mind of the ordinary man when the word " mathematics " is mentioned. Most people know that Algebra is a kind of arithmetical calculation, where symbols such as the letters of the alphabet take the place of the symbols such as 1, 2, 3, etc., which designate actual numbers. The word " algebra " is Arabic in origin, and makes its first appearance in a work by an Arab mathematician, Al Khowarazmi, in the ninth century A.D., but of course the operations in Mathematics which we call " algebraic " are much older and date back, in a rather rudimentary form, even to the Egyptians. A Greek, Diophantos of Alexandria, wrote the first Western work on it about the middle of the fourth century A.D., and actually the Hindus had brought this subject to a higher pitch of development than the Greeks, whose peculiar genius was more at home in Geometry. It was from the Hindus that the Arabs learnt this system and brought it to the West. In the solution of equations, there is a well-known operation in which quantities on one side of an equation are brought over to the other side with a changed sign. This transposition was considered to be a reunion of separated quantities and was regarded by the ancients as an operation of great importance. When the Arab, Al Khowarazmi, wrote his treatise, he called it " al-jabr m' wa'l muquabalah," the word " jabr " referring to this reunion. The word " muquabalah " referred to another operation in equations, where a symbol appearing on both sides of the equation with the same sign is taken away from each side. (" Al " is the definite article in Arabic.) In consequence, when this treatise became well known to European scholars in the middle ages, they referred to it by the first word in its Arabic title, corrupting this into our " algebra."

NUMBER

We have already realised that the first mathematician was he who thought of the number " three," for instance, quite apart from three pebbles, three bits of meat, three dogs, or three *of any particular thing*. This " emptying " of every physical property out of the counted things, except their mere existence as individual things, is an example of what the philosopher calls " abstraction." The primitive mathematician to whom we have referred was abstracting from the things themselves every quality except their capacity to be counted. For him it did not matter what three things were involved; indeed they did not even need to be the same kind of thing—a dog, a tree and a pebble would serve as a

physical picture of "three," as well as of the groups mentioned. He recognised that when he put *any* three things into a heap of any four things he always got the same number of things in the larger heap, namely seven. He did not find that four dogs and three dogs, for example, gave a group of dogs whose number was different from the number of pebbles he obtained when four pebbles were placed beside three pebbles. The apparent triviality of these illustrations must not be scorned, since they are vital to the understanding of the scientific process we call "generalisation." Recognising this feature as true of all additions of heaps or groups, he gradually began to think of the addition as not being effected on the groups *but on the numbers*, and so he arrived at the "identity"

$$4 + 3 = 7$$

We are using modern symbolism, of course. The ancient and mediæval people wrote that result with different symbols, but essentially it was numbers which they added and not *things*. The numerals 3, 4, 7 are modern adaptations of Hindu signs; + is a symbol which did not come into use until the fifteenth century; and the two parallel strokes =, representing "is equal to," are also of recent origin. The reader should bear in mind that in every case our symbolism is most unlike the symbolism of the Greek, the Hindu, the Arab or the mediæval European, but that the processes indicated by the symbolism are alike.

Another thing which this acute observer of distant ages noticed was, that when he put a group of four things beside a group of three things he had the same number as if he put a group of three things beside a group of four. Again this looks terribly trivial but it seems to bring out the correct use of the sign +; we nowadays write down this result in the form

$$4 + 3 = 3 + 4$$

The left side reads "four plus three" and means the result of adding three to four; the right side reads "three plus four" and means the result of adding four to three. As the result is true when any other pair of numbers is substituted for 3 and 4, we write the general result thus:—

$$a + b = b + a$$

and the reader at once thinks of algebra. Strictly speaking, this is not algebra. At present we are simply stating, in a more general symbolic form than we did above, that the result of adding any two numbers together is independent of the order in which they are placed. We use any convenient symbol (and experience has shown that the letters of various alphabets are the most convenient) to represent a number which we need not specifically state in numerical value. (This sort of device enters into many operations other than arithmetical. For example, chemists use a peculiar symbolism to state important results concisely and briefly. Thus *H* stands for a unit weight of hydrogen; *O* for 16 units of weight of oxygen; *Cl* for 35.5 units of chlorine and so on, some hundred or so of such symbols being tabulated in any work on Chemistry.) The mathematician has a word which he associated with the symbolic statement

written above. He says that the operation of addition is "commutative." Take another of these apparently trivial statements. Suppose we wish to add 4 and 3 and 5. Of course the order in which we write them down is immaterial; but as they stand it is also immaterial whether we add 3 to 4 and then add 5 to that result, or add 5 to 3 and then add that result to 4. We express this by writing

$$(4 + 3) + 5 = 4 + (3 + 5)$$

Here we have an example of the use of "brackets," as the curved strokes ( ) are called. On the left side, the brackets enclosing 4 and 3 indicate that they should be added first and then 5 added to the sum; while on the right side, the enclosing of 3 and 5 indicates that addition of them should be effected first and this sum added to 4. The mathematician again has a special word to suit this occasion. He speaks of a law of "Association," and he writes it entirely symbolically as

$$(a + b) + c = a + (b + c)$$

and of course, by his law of Commutation, either of these "expressions" is equal to $(a + c) + b$ or $a + (c + b)$ or $(b + c) + a$, etc.; and finally, as this is so, he can, if he wishes, do without the brackets and write the complete sum as $a + b + c$, or $a + c + b$, or $b + c + a$, etc. As a matter of fact he can invent quite fiendish problems involving the use of brackets, as most schoolboys know, leading to dozens of pitfalls for the unwary; but in general the errors into which the scholar falls are due to his failure to keep before his mind the simple meaning of the symbolism used.

The minus sign offers no difficulty in this connection. If we add 6 to 5, and subtract from this result 4, we express this in the most rigidly correct symbolic way as

$$(5 + 6) - 4$$

But, of course, we get the same result by first subtracting 4 from 6 and adding the result to 5, which is correctly written as

$$5 + (6 - 4).$$

Or we can find the same answer if we take 4 from 5 and add 6 to the difference, which is

$$(5 - 4) + 6$$

and so on. As all these are equivalent, the mathematician once more simplifies his symbolism somewhat by writing

$$5 + 6 - 4,\ 5 - 4 + 6, \text{ etc.}$$

according to his convenience or choice.

Take another example which raises one little point of considerable importance. Suppose we add 3 to 7 and then subtract this result from 12. In rigid symbolism this is

$$12 - (7 + 3).$$

Now will it do simply to "wipe out" the brackets and write this

$$12 - 7 + 3?$$

Clearly not; for one result is 2, and the second, which says "subtract 7 from 12 and then add 3 to that," gives 8. In fact $12 - (7 + 3)$ turns out to be the same as $(12 - 7) - 3$, or $12 - 7 - 3$, which says "subtract 7 from 12 and subtract 3 from that." Again let us subtract 3 from 7 and then subtract this result from 12. This is symbolised by

$$12 - (7 - 3)$$

and this is not at all the same as $12 - 7 - 3$, but is actually the same result as $(12 - 7) + 3$, *i.e.* the result of subtracting 7 from 12 and *adding* 3 to the result. Thus, in more general symbolism,

$$a - (b + c) = (a - b) - c$$

and

$$a - (b - c) = (a - b) + c$$

so that, stated as a matter of routine, if we remove brackets before which occurs the minus sign we must change the signs within. Of course the above expressions can be written respectively as $a - b - c$ and $a - b + c$; but as we cannot add or subtract many numbers "all at once," but must group them in pairs at each stage, brackets are always implied although they need not always be written. It is over this changing of the sign inside brackets preceded by the minus sign that the schoolboy is frequently so confused. For example, let us write down

$$16 - [10 - (5 + 3)]$$

Now strictly this means :— "Add 3 to 5 and subtract the result from 10; take this result away from 16." The answer is of course 14, and this is the same as

$$16 - [10 - 5 - 3]$$

and this again the same as

$$16 - 10 + 5 + 3.$$

In short, if one interprets the top expression correctly in words one cannot go wrong; but there is a purely mechanical way of removing the brackets one by one, *working from the inside outwards* and changing signs where necessary, so that

$$\begin{aligned} & a - [b - (c + d)] \\ = \; & a - [b - c - d] \\ = \; & a - b + c + d \end{aligned}$$

and

$$\begin{aligned} & a - [b - (c - d)] \\ = \; & a - [b - c + d] \\ = \; & a - b + c - d \end{aligned}$$

Trial with any actual numbers will always verify this.

We now meet another result which raises an awkward but very fundamental question. Suppose I write down

$$16 - (3 - 7)$$

This says " Subtract 7 from 3 and subtract the result from 16." This appears to be nonsense : you cannot subtract 7 from 3. But if a friend borrows £7 from you, and only repays you £3, he appears to have achieved the feat. He leaves you the poorer by £4. Indeed the natural exclamation (creeping into colloquial use to-day), " I was minus £4 on that deal," might rise to your lips. So if I write

$$16 - (3 - 7) = 16 - 3 + 7 = 20$$

conforming to the rule of changing the sign, I can think of it as representing the financial state of your friend who, beginning with £16 in his pocket, borrowed £7 from you and only repaid £3, thus " taking away " from his own little pile £(3 — 7) and yet being £4 to the good ! So it appears that such an expression as

$$a - (b - c)$$

need not be altogether nonsense even if c is greater than b, and that writing it as

$$a - b + c$$

may still be quite valid. With this hint we leave the point for the moment and will return to it later.

We are all familiar with the multiplication table and the meaning to be attached to 3×4 for example. Our primitive mathematician must have noticed the interesting fact that four heaps of three things gave the same number of things as when he put three heaps of four things together. As we write it, that result is

$$4 \times 3 = 3 \times 4$$

The left side reads " four multiplied by three," the right " three multiplied by four." In more general symbolism

$$a \times b = b \times a$$

or multiplication of two numbers is " commutative."

Actually, the cross sign × is frequently omitted *when we use letters to represent numbers*, so that the product $a \times b$ is more often than not written $a\ b$, and $b \times a$ written $b\ a$. We naturally cannot omit the cross when we use actual numbers ; for 34, for example, is thirty-four and not three times four, which must be written 3×4, or sometimes 3.4, the dot printed on the line sometimes taking the place of the cross. (The dot on the line must not be confused with the dot above the line, as in 3·4, indicating the decimal point.) This privilege accorded to letters, and not to the numerals, renders necessary a short digression here ; for if we actually did want to suggest that a number had two digits, the first one being a and the second one b, we should have to write it $10a + b$. This serves to remind us of the universal convention in the writing or printing of our numbers, that the last number is in the " unit's place," the one before that in the " ten's place " and so on, so that

$$356 = 6 + (5 \times 10) + (3 \times 100)$$

But this convention is not used in our symbolism of letters. Actually $a\ b\ c$ means that we multiply a by b and that product is then multiplied by c. If we wish to suggest a number of three digits whose first digit is a, second b, third c, we must write it $c + 10b + 100a$. Beyond that measure of caution in interpretation the omission of the cross causes no inconvenience.

Two very convenient abbreviations are used when, in addition or multiplication, the same number is repeated several times. Thus :

$$a + a + a + a + a$$

can be written $5a$, the economy in writing being obvious. Again

$$a \times a \times a \times a \times a$$

or $$a\,a\,a\,a\,a$$

is generally written a^5, the 5 being printed in small type at the top right hand corner of the letter to distinguish the result from $a5$ which is actually the same as $5a$, as we know. We then speak of the 5 in a^5 as an " index " or " power," referring to a^5 in the words " a to the fifth power " or " a to the power 5." Looking now at the four " expressions " ab, ba, a^b, b^a, we recognise that the first two mean the same number, but that in general this is not the same number as either the third or fourth expression represents; nor indeed do the third and fourth expressions represent the same number; a^b represents the result of multiplying a by a, and that product again by a and so on, until the number of a symbols involved has reached b, and b^a represents similarly $b \times b \times b \times \ldots$, a times.

There remains the fourth fundamental operation of arithmetic, namely, division. This is the inverse of multiplication, so that when we write $4 \times 3 = 12$, we can also write it $12 \div 3 = 4$ or $12 \div 4 = 3$. Actually the division sign, $\div$, is frequently replaced nowadays by the " solidus," $/$, and the divisions above are often written $12/3$ and $12/4$. Of course the operation of division is not commutative; for certainly $12/3$ is not the same as $3/12$. Indeed in confining ourselves, as we have implicitly done so far, to the numbers by means of which we *count discrete objects*, we have no meaning at all for $3/12$ if " number " is to refer exclusively to the numerals of the ordinary table. For that matter $12/5$ or $12/7$ would have no meaning either, while $12/2$ and $12/6$ would; so that if we had no other numbers than 1, 2, 3, 4, etc., a/b might or might not have a meaning, and even if a/b had a meaning, b/a would not. This introduction of the word " meaning " deserves a little more consideration. It is often said that when we meet an expression like $a + b$ or $a - b$, a means *any* number and b means any number. This is hardly a correct way of stating the situation. In any specific case a must mean *some* number and b must mean *some* number, and the correct way of looking at the matter is this. If a represents some definite number and b represents a definite number, the same or not as a, then the expression $a + b$ has a meaning, so also has $a - b$ (with perhaps a slight reservation for the moment if b is greater than a); so also has $a\ b$. But without some extension of the

meaning of the word " number " a/b might not have a meaning. That extension we now make.

Naturally we are concerned now not only with discrete, enumerable objects, but with the results of breaking them into parts and the evolution of ideas about the dimensions, weights or other physical properties of the parts, so that on some criterion parts could be called equal or unequal in magnitude. Hence obviously arise the notions of half, third, quarter, etc. These are, of course, introduced into an extended number system in the form $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc., or sometimes in a more convenient form for printing $1/2$, $1/3$, $1/4$. In the earliest records of arithmetical calculation among the Egyptians, the only fractions used were unit fractions, *i.e.* fractions with unity in the numerator. Thus what we would write as $2/9$ they wrote as $1/6 + 1/18$; and $2/95$ was written as $1/60 + 1/380 + 1/570$. The Greeks, Romans and Hindus used a symbolism which is equivalent to our way of writing general fractions. So we now " give a meaning " to $\frac{a}{b}$ or a/b when a and b mean " integral numbers " or " integers " such as 1, 2, 3, 4, etc., even when the number represented by a is not exactly divisible by the number represented by b; for we can picture a physical operation which breaks something into b equal parts and then selects a of them as another recognisable thing. Actually, this way of looking at the matter is only legitimate if a is less than b; the fraction is then a " proper fraction." If a is greater than b we must think of several things, only one of which is broken up into b parts. The number of whole things still left gives us a picture of an integer which is part of this " improper fraction," and the combination of the integer and the proper fraction we call a " mixed number," so that if we write the improper fraction $16/7$, it can also be represented by the mixed number $2\frac{2}{7}$. The number system now includes both integral and fractional numbers, and we can adapt our symbolism to meet the new situation by admitting that a single symbol such as a can now represent not only an integer as heretofore but also a fractional number, proper or improper, if need be. The rules for addition, subtraction, multiplication and division of fractions explained in every text-book of Arithmetic then enable us, as before, to give a meaning to $a + b$, $a - b$, $a\,b$, a/b, provided a and b represent definite numbers. The commutative and associative principles still remain in force. If we care to, we can utilise the decimal notation, in place of the usual fractional form, to indicate the fractional numbers proper or mixed numbers. There is, however, this difference, of some importance as we shall see presently, that whereas a proper fraction can always be indicated by using a finite number of ordinary figures, the corresponding decimal expression may be unending, although the figures recur. Thus:

$$\tfrac{6}{7} = \cdot 857142857142857142 \ldots$$

usually written $\cdot\dot{8}5714\dot{2}$.

We have by no means exhausted all the possibilities of number, as the Greeks recognised in their day because of their geometric genius. Since $2 \times 2 = 4$, $3 \times 3 = 9$, $4 \times 4 = 16$, $5 \times 5 = 25$, etc., it is sometimes said that the numbers 4, 9, 16, 25, etc., have square roots, while numbers

like 2, 3, 5, 6, 7, 10 . . . have no square roots and so are not "perfect square" numbers. Take 2, for example; we can apply the well-known process taught in every text of Arithmetic for extracting square roots. The process works perfectly but *never ends* (except, of course, when necessity or loss of interest compels us to stop). Thus the square of 1·4 is less than 2, but the square of 1·5 is greater; the square of 1·41 is less than 2, the square of 1·42 is greater; the square of 1·414 less, of 1·415 greater; the square of 1·4142 less, of 1·4143 greater, and so on as far as we care to go. So we can arrange a class of ascending numbers such as 1, 1·4, 1·41, 1·414, 1·4142, . . . whose squares are all less than 2 but progressively increasing towards 2 *as near as we like*, provided we take sufficient trouble. Also we can arrange a series of descending numbers such as 1·5, 1·42, 1·415, 1·4143, . . . whose squares progressively decrease towards 2 yet never quite reach it. The gap can be closed up to any degree we please, but can never be absolutely closed. The situation is tantalising, but the Greek had no difficulty in admitting that the square root of 2 really exists by adopting the following line of argument. When he reasoned about number, he nearly always pictured a number as representing some geometric magnitude such as length, area or volume. Let us draw a straight line on paper, mark a point O on it and then mark points A, B, C, D . . . so that OA = AB = BC = CD = . . . each step being one

X

Z

O A B D

inch, say. The lengths of OA, AB, OC, OD, . . . can then be considered to represent in a geometrical sense the numbers 1, 2, 3, 4. . . . Further, by dividing the segments OA, AB, BC, . . . into equal parts as finely subdivided as we please, we can represent all the various fractional numbers, proper and improper alike. None of these points, however, will represent the square root of 2, since it cannot be expressed as a decimal *with recurring figures*, which as we know can be reduced to an ordinary fractional form with a finite number of figures in numerator and denominator. But let us construct a square OAXY on the side OA. By the Pythagorean proposition, the square on the diagonal OX is equal to the square on OA plus the square on AX, *i.e.* to the square of 1 + the square of 1, or 2. So if we mark by means of a compass point Z on the line OABC, so that OZ = OX, then just as OB can be said to "represent" the number 2, and OC the number 3, etc., in exactly the same sense OZ will represent a number whose square is 2. In short, we deliberately extend our number system to include numbers represented by any length we like marked out from O to some point on the line. In this way, by suitable constructions, the square root of any number can be given such a pictorial representation. Such considerations justify our introduction of the square

roots, cube roots, fourth roots, etc., of any number we please into our number system. We distinguish them from the integral and fractional numbers by calling them "irrational" numbers, but this epithet must not be interpreted as "unreasonable"; for the existence of these numbers is so "reasonable" an assumption that a tremendous amount of mathematics, absolutely vital for practical calculations in our scientific and engineering pursuits, would be impossible without them. So when we say that a letter a represents an irrational number, *e.g.* the seventh root of 5, we mean that a satisfies the relation

$$a^7 = 5.$$

We postulate also that if a represents such an irrational number and b another number, rational or irrational, then $a + b$, $a - b$, ab, a/b, also represent numbers and that $a + b$ is the same number as $b + a$, and ab the same number as ba. (It should be noted that if a and b are irrational numbers it cannot be concluded that ab is necessarily irrational. Thus $\sqrt{2}$ and $\sqrt{8}$ are irrational numbers; but $\sqrt{2} \times \sqrt{8}$ is not, for it is the same as $\sqrt{16}$ which is 4.) In making this postulate we are appealing to the "principle of continuity," for inasmuch as we can always find a rational number, integral or fractional, which is as near as any assigned amount, however small, to the irrational number in question, we take it that the laws which are true for rational numbers are also true for irrational.

In a former paragraph of this section we drew attention to the doubt about the validity of an expression such as $a - b$ if we knew that b represents a larger number than a does. Even so we saw that the operation indicated was not entirely unreasonable. We can now make a final extension of the number system so as to remove all trace of hesitation about accepting such an expression. Suppose you walk 6 feet in a given direction and then turn right round and walk back 4 feet, you have walked 10 feet no doubt, but the final effect is to leave you only 2 feet from where you started. If you walk 6 feet to the right and then 8 feet to the left, you are once more 2 feet from the initial mark. How can one distinguish these two cases from one another by a concise symbolism? The experience of the mathematician has guided him to a very simple answer to that question. He represents 6 feet one way by $+ 6$ and 4 feet the other way by $- 4$, thus introducing what he calls "directed numbers," some of which are "positive" and some "negative." (It is entirely a matter of choice and convenience which he chooses as the "positive direction" and which the "negative direction.") He then writes an account of the first walk thus:

$$(+6) + (-4)$$

the result being $+ 2$. Note that in this the $+$ sign has two meanings, one to indicate the direction and one to indicate that a certain effect represented by $- 4$ is being added to another effect represented by $+ 6$, the sense of the word "addition" being rather more general than before. The second walk is represented by

$$(+6) + (-8)$$

and the result is -2; for now you are 2 feet away from the start in the negative direction. The first of these can then be contracted to

$$6 - 4 = 2$$

the second to

$$6 - 8 = -2$$

So now at one swoop we double all the numbers in our system by this convention of "directed-ness"; for to any of our previous numbers rational or irrational, integral or fractional, regarded as a positive number, there corresponds a negative number. Our letter symbols a, b, etc., now may be considered as representing negative numbers if necessity should arise. Care is needed here. Though we may not necessarily write a minus sign before a letter, say b, yet we can assume if necessary that it is representing a negative number. Thus let us consider

$$a + b$$

where a represents $+9$ and b represents -5. As indicated above, we can think of this as a walk of 9 northwards followed by a walk of 5 southwards, the result being 4 northwards, so that $a + b$ represents $+4$. The question at once rises to our lips, What about $a - b$ if b is a negative number? That can be answered by reference to a simple situation. Harry walks 9 feet north and James 5 feet north; how far is Harry away from James? Four feet to the north of him of course; *i.e.*

$$(+9) - (+5) = +4$$

But now Harry walks 9 feet to the north and James 5 feet to the south; how far is Harry now from James? The answer is of course 14 feet to the north; *i.e.*

$$(+9) - (-5) = +14$$

There we have it again: "Two negatives make a positive." We need have no hesitation about changing the sign inside the brackets if there is a minus sign outside. We could go on multiplying illustrations from all sorts of human pursuits and activities. For example, we know that there is a temperature on all thermometers marked 0, the "zero"; temperatures warmer than this are marked + (or at least that is implied if the sign is omitted), and temperatures below are marked —. How much does the temperature a differ from the temperature b? Always by $a - b$. Try it in any case. How much does $+30°$ differ from $+20°$? Answer, $(+30°) - (+20)$, *i.e* $+10°$ or ten degrees *higher*. How much does 20° differ from 30°? Answer $(+20°) - (+30)$ *i.e.* $-10°$ or ten degrees *lower*. How much does $+30°$ differ from $-20°$? Answer $(+30) - (+20)$, *i.e.* $+30 + 20$, or $+50$, or fifty degrees *higher*. Obviously correct, for from 20 below a mark to 30 above it is 50 steps. Again, walk up ten steps on the stairs, turn, and come down fifteen steps. Where are you? Answer $(+10) - (+15)$ steps *up*; *i.e.* (-5) steps *up*; *i.e.* really 5 steps *down*. One last illustration, so as to show what is meant by ab when a and b may represent negative numbers as well as positive. When a train travels through a station going north and we know it is travelling at a speed of 500 yards a minute, where is it 4 minutes after passing through? It is

2,000 yards away to the north. Let us now represent time which elapses after the instant when the train was at the station by positive numbers, and time which elapses from earlier moments until the instant of passage through the station by negative numbers. We symbolise the result just given by

$$(+500) \times (+4)$$

which is $+2,000$.

But where is the train 4 minutes later if it is going south? The answer is clearly 2,000 yards to the south; and this is brought within our symbolism if we agree that

$$(-500) \times (+4) = -2,000$$

so that the product of a negative number and a positive number is a negative number. Or look at it another way. When the train travelled north, where was it 4 minutes *earlier* than the instant of passage? Clearly 2,000 yards to the south, and again this is right if we agree that

$$(+500) \times (-4) = -2,000.$$

Lastly, and most instructive of all; where was the train, if it is travelling *south*, 4 minutes *earlier* than its moment of passage through the station? Without a doubt 2,000 yards away *to the north*. Again all right if we agree that

$$(-500) \times (-4) = +2,000$$

or the product of two negative numbers is a *positive* number.

It is absolutely a hopeless task to grasp the nature of mathematical reasoning, unless the reader understands the meaning of those symbolic representations which indicate the fundamental operations of arithmetic as carried out on all the variety of numbers which can be conceived by the mathematicians, and unless it is realised at the same time that these conceptions have not been spun out of an unregulated imagination, but that they have been checked at every turn by reference to many activities and occurrences in our physical world, of which only an extremely limited selection has been indicated in the preceding pages.

ALGEBRA

Having invented this concise symbolism to indicate the results of applying the four fundamental operations to the numbers of his system, the mathematician at all times has delighted in extending the range and power of his symbolic method far beyond the possibilities conceived by his ancestors.

Most people know that Algebra is extremely useful in " solving problems " ; that there are, in fact, certain calculations arising in every region of practical activity, which would be entirely impossible without some symbolic way of representing numbers which are unknown at the outset but which have to be found. Every text-book of Algebra contains a selection of such problems so that the pupil, by experience of varied types, may learn to deal with them if they arise in his own pursuits. The solution of such problems involves a widening and deepening of the technical

operations indicated in the previous section, and so the text-book generally devotes its earlier chapters to practice in the handling of "formulæ." The reading and understanding of a formula is an absolute necessity for an engineer, chemist, physicist or architect, to single out a few professions. For example, to take the first one that comes to hand from an engineer's table-book, C^2Rt. This has a meaning if C and R and t have meanings. Actually it tells you that you multiply the number indicated by C by itself, then multiply that product by the number which R represents, and that product by the number presented by t. As used by the engineer, C is the number of ampères in a current, R is the number of ohms in the resistance of a wire, and t is the number of seconds for which the current has been running, and the calculated value of the formula indicates to him the amount of heat which has been developed in the wire. In these days of electric heaters there is no need to stress the "usefulness" of the information which C^2Rt compresses into itself so compactly.

Take another one, this time an "expression" from a book on Algebra, $x^2 - 5xy - 7y^2$. This expression has three "terms." The first term, x^2, tells you to square the number indicated by x; the second term tells you to multiply the number indicated by x by the number indicated by y and that product by 5; the third term tells you to square the number indicated by y and take 7 times that result. You then subtract the second term from the first, and from the difference you again subtract the third term. An operation which requires six lines of print to explain in ordinary words is indicated by the printed letters in one third of a line.

Then there are operations of great service which are indicated by a symbolism such as this:

$$a(b + c),\ a(b - c),\ (a + b)(c + d), \text{ etc.}$$

Take $a(b + c)$ for instance. It indicates, by this use of the brackets, that b and c are to be added and that a is then multiplied by the sum. Try this on $5(7 + 3)$. The result is 5×10, or 50; but notice that 5×7 is 35 and 5×3 is 15 and these add to 50. That is

$$5(7 + 3) = 5 \times 7 + 5 \times 3.$$

This suggests that

$$a(b + c) = ab + ac$$

and trial with any numbers always justifies this general statement.

Similarly, trial with any numbers always justifies

$$a(b - c) = ab - ac$$

and we can extend this indefinitely thus

$$a(b + c + d - e \ldots) = ab + ac + ad - ae \ldots$$

This is called "distributing" a among the terms inside the bracket and the result is called the "Distributive Law."

Take a still wider form

$$(a + b)(c + d)$$

As a matter of trial, insert 10 for a, 8 for b, 4 for c, 3 for d. The result is:

$$18 \times 7 \text{ or } 126.$$

Now notice that ac is 40, ad is 30, bc is 32 and bd is 24. Add these four numbers and the result is 126. So this suggests that

$$(a + b)\ (c + d) = ac + bc + ad + bd$$

and trial with any numbers will always justify it. But actually, if we are satisfied that our previous result is correct, we need no numerical trials to convince us that this is also correct; for we have only to apply the Distributive Law twice to "prove" it. Thus

$$(a + b)\ (c + d) = (a + b)\ c + (a + b)\ d$$

where we regard $(a + b)$ for the moment as one numerical entity. Now apply the law again to the right side

$$(a + b)\ c + (a + b)\ d = ac + bc + ad + bd$$

and the proof is completed.

Again take $(a + b)\ (c - d)$; it is equal to $(a + b)\ c - (a + b)\ d$, and this is equal to $ac + bc - (ad + bd)$ and this to $ac + bc - ad - bd$ *if the rule about changing signs inside the bracket is all right here*. Try it on any numbers and it is so. Thus with the numbers used above $a + b$ is 18 and $c - d$ is 1, so the result is 18; 18 is also equal to $40 + 32 - 30 - 24$. Finally consider

$$(a - b)\ (c - d).$$

This is $(a - b)\ c - (a - b)\ d$, and that is $ac - bc - (ad - bd)$, or $ac - bc - ad + bd$, and numerical trial again justifies the general rule for changing the sign on removing the bracket after a minus sign.

Now all these separate results can be summarised in one result, provided we remember that the letters may represent *negative* numbers, if need be, as well as positive. Thus

$$(a + b)\ (c + d) = ac + ad + bc + bd$$

is a truth, even if some of the letters represent negative numbers. Put $+ 9$ for a, $- 5$ for b, $+ 4$ for c, $- 2$ for d.

The left side is

$$[(+ 9) + (- 5)]\ [(+ 4) + (- 2)]$$
$$\textit{i.e. } (+ 4) \times (+ 2) \text{ or } + 8.$$

The right side is

$$(+ 9) \times (+ 4) + (+ 9) \times (- 2) + (- 5) \times (+ 4) + (- 5)\ (- 2).$$

Now comes a clinching test concerning the products of positive and negative numbers. If what we have pointed out in the previous chapter is generally true, then

$$(+ 9) \times (+ 4) = + 36$$
$$(+ 9) \times (- 2) = - 18$$
$$(- 5) \times (+ 4) = - 20$$
$$(- 5) \times (- 2) = + 10.$$

Add the four numbers; *i.e.* add "in the algebraic sense," *taking account of the signs*; the result is as follows: $(+36)+(-18)$ is $+18$, $(+18)+(-20)$ is -2, and $(-2)+(+10)$ is $+8$, and $+8$ is what we got above.

Special cases of these results are extremely useful at times. Here are two which are always turning up:

$$(a+b)^2 = a^2 + 2ab + b^2$$
$$(a-b)^2 = a^2 - 2ab + b^2$$

or, in words, "the square of the sum of two numbers is equal to the sum of their squares together with twice their product, and the square of their difference is equal to the sum of their squares less twice their product." But how compact the symbolic statement is as compared with the verbal.

Here is another valuable little "friend in time of need":

$$(a+b)(a-b) = a^2 - b^2.$$

Another piece of skill which the mathematician must cultivate, as a craftsman must cultivate skill with his tools, concerns the same kind of operations as those just mentioned looked at from the opposite point of view. We can easily see that

$$\begin{aligned} &(3a+4b)(2a+7b) \\ &= 6a^2 + 8ab + 21ab + 28b^2 \\ &= 6a^2 + 29ab + 8b^2. \end{aligned}$$

But suppose I write down

$$5a^2 + 41ab + 8b^2.$$

Can I do the reverse operation on this and represent it as the product of two "factors"? Actually I can "factorise" the expression; it is equal to $(5a+b)(a+8b)$. But, as a matter of fact, it is not always possible to do this for any expression like the above with any random numbers written down in place of the 5, the 41, and the 8; at least, not with the numbers which we have considered so far, *i.e.* the "real" numbers, integral or fractional, rational or irrational, positive or negative. Even when the factorisation is possible the numbers in the factors do not generally come out so nicely and may involve cumbersome fractions, or even irrational numbers. For example, $a^2 + b^2$ has no factors like the above; $a^2 + 6ab + 7b^2$ has, but they are

$$[a + (3 - \sqrt{2})\,b]\,[a + (3 + \sqrt{2})\,b].$$

Cultivation of skill in factorisation, combined with the recognition of the occasions when it is possible and when not, is one of the most useful accomplishments which a mathematician can cultivate, and a good number of pages in every book on Algebra is devoted to teaching all the methods and artifices which experience has revealed as necessary for the purpose and for the multifarious types of expressions which may occur.

Of course the examples of an algebraic expression which have been written above are relatively simple ones. An expression might consist of many more terms and each term might be much more complex in structure. In addition we could build still more complicated expressions consisting of products, quotients and powers of those just indicated.

Here is one which has a special significance for any reader who is interested in wireless matters and may have heard of the "impedance" of an electric circuit, a word bandied about freely in conversation between wireless enthusiasts:

$$\sqrt{\left\{\left(2\pi Lf - {}_{2\pi kf}\right)^2 + R^2\right\}}$$

As an algebraic expression it tells you to carry out a group of calculations. First you multiply the number f (which is to be read as an abbreviation for "the number represented by f") by the number L and the result you multiply by the number π and double. From that you subtract the number obtained by dividing the product of the numbers f, k, π and 2 into unity. This result is squared and then added to the square of the number R, and you then extract the square root. An engineer's pocket-book in which you will find this formula will tell you that this is the impedance of an electric circuit whose "resistance," "inductance" and "capacity" are equal to the numbers R, L and k respectively in the usual electric units and in which there is an alternating current of frequency f. The number π is the ratio of the circumference of a circle to its radius. You would also find in the same pocket-book, in the same connection, another expression such as this :—

$$\frac{E}{\sqrt{\left\{\left(2\pi Lf - \frac{1}{2\pi kf}\right)^2 + R^2\right.}}$$

which suggests that you should divide the number calculated above into the number E, the object of this division being to obtain the so-called "peak" value of the alternating current excited in this circuit when an alternating electromotive force, whose "peak" value in E, is applied to it.

Now let the reader be under no misapprehension that this symbolic writing is only of value as a kind of convenient shorthand, indicating concisely certain necessary and useful practical calculations. That would be a painfully inadequate view of the situation. After all, these expressions were not originally written down at the dictation of some eminent mathematician. They were *proved.* They were deduced by plain, ordinary reason from certain principles and, what is more, the deduction *would have been a sheer impossibility without the symbolism.* It will be illuminating if we just refer to those principles for a moment. First of all there come the "physical principles," *i.e.* the laws discovered by experiment and trial, in this case the laws of electric circuits first propounded by men like Ohm, Faraday and Maxwell. These enable one to write down an "equation," which is just a statement of an equality between the values of two mathematical expressions. The experimenter, the physicist, has now had his say and the mathematician takes up this equation, absolutely unconcerned as to what the symbols in the equation "mean." To him they are purely abstract quantities to be treated according to the principles of his science, among which we first of all meet "logical principles," which are

those universal rules admitted on all hands to be vital to any kind of reasoning. Such, for instance, are the statements that "two things which are equal to a third, are equal to each other," or "remove equals from equals and the remainders are equal," etc. . . . But there are, in addition, principles bearing on the handling of his special symbolism, mathematical principles proper, *e.g.* the laws of commutation, association, distribution referred to above, and others which we cannot here mention or illustrate. This may help the reader to understand that algebraic symbolism is not merely a convenient "language," but is an indispensable part of the machinery of certain kinds of reasoning, and that the mathematician proper, the "pure" mathematician as he is conveniently named, is more interested in his processes of deduction and the development of the range and power of his symbolism than in the useful, practical formulæ which he, and he alone, can obtain.

The reference just made to an "equation" may remind the reader that when we begin to work out a problem we always expect to "turn the problem into an equation"; so that equations are vitally connected with problems. Yet it is more instructive (or so the writer thinks) to show how the mathematician would come to be interested in equations, quite apart from their practical value in discovering the answers to problems.

Let us consider the letter x as representing some number, and let us write down a few algebraic expressions in which it is involved :—

$$4x - 8$$
$$3x + 4$$
$$x^2 + 2x - 68$$
$$x^3 + 7x^2 + 5x + 9$$
$$x^4 - 10x^3 + 8x^2 - 7x + 1.$$

The first two expressions only involve x itself and not a square, or third power, or fourth power, etc. . . . of x. They are called "linear" expressions; the third one is called a "quadratic" expression, because it involves the second power or square of x (*x quadratus*) as well as the first power; the third is called a "cubic" expression because it involves the cube of x; the fourth a "quartic," and so on. It is obviously a simple matter to insert a special number for x, and calculate the numerical value of any of these expressions which corresponds to the special value of x. As we "vary" the value of x, the value of any such expression also varies; for clearly the latter depends on the former. In technical language we often refer to x as an "independent variable" and then call any expression which involves it, and which is therefore dependent on it as regards numerical value, a "function of x." But what interests the mathematician is the inverse operation to what has just been indicated. He asks, "If I give a numerical value to the expression or function, can I find what is the value of x which will fit this; or indeed is there a value which will do it"? Let us try the mathematician's puzzle with some of the expressions above. Take the first one and ask what is the value of x which will make it have the value 12. This gives us the "equation"

$$4x - 8 = 12.$$

Now we apply the *logical* principle, " add equals to equals and the sums are equal." Let us add 8 to each side

$$4x - 8 + 8 = 12 + 8$$

or $$4x = 20$$

and so $$x = 5.$$

We see at once why we add 8 to each side; it gets all the terms indicated by actual numerals together; it amounts to transposing — 8 to the right side and changing the sign. It was this *uniting* process to which the Arabs referred when they used the word " al jabr " and this, it will be recalled, gave the name of the subject by reason of the title of an Arabic book.

Let us try to answer the same question for the third expression; let us ask if there is a value for x which will make $x^2 + 2x - 68$ equal to 12. The reader will find that if he puts x equal to 8, the quadratic expression is equal to 12; for x^2 is then 64, $2x$ is 16; so their sum is 80 and thus if 68 is taken away, 12 remains. Yet obviously it would take more " guessing " than in the previous instance to arrive at this value of x. Is there no routine way of getting at the required result? Well, there is, and there is also a modification of it which yields the result very quickly in certain cases, provided one is expert at the process of factorisation mentioned earlier. The present example happens to be one in which the modified method works. Let us write down our equation :—

$$x^2 + 2x - 68 = 12.$$

Let us apply the logical principle that if we remove equals from equals, then equals remain and take away 12 from each side

$$x^2 + 2x - 68 - 12 = 12 - 12$$

or $$x^2 + 2x - 80 = 0.$$

This is the " transposition " process working a little differently than in the previous example with the linear function. Now anyone with experience in factorisation will split the left hand expression above into two factors; they are $x - 8$ and $x + 10$, and the reader at all events can satisfy himself that this is so; for by repeating the process already referred to in stating the principle of distribution he will find that

$$\begin{aligned}(x - 8)(x + 10) &= x(x + 10) - 8(x + 10)\\ &= (x^2 + 10x) - (8x + 80)\\ &= x^2 + 10x - 8x - 80\\ &= x^2 + 2x - 80.\end{aligned}$$

So we again modify the equation into

$$(x - 8)(x + 10) = 0.$$

The answer, x is equal to 8, is now justified, for if we make x equal to 8, one of the factors becomes zero and the other 18, and 18 times nothing is just nothing. But we have discovered something more; for if we put -10 for x (note the minus sign most carefully), then one of the factors is

0 and the other is -18 and the product of 0 and -18 is 0. So if we substitute -10 for x in $x^2 + 2x - 68$ we should get 12, and this is so, for $(-10)^2$ is $+100$ (remember that "the product of two negative numbers is positive" is a rule satisfied by our symbolism); also $2x$ is -20 and $+100 - 20 - 68 = +80 - 68 = 12$. Of course the choice of 12 as the number to which the quadratic expression is to be equal made this method "work simply." Had we chosen another number, the factorisation would not have been so easy; for instance, suppose we had asked for the expression to be equal to 10 instead of 12, it would be a little more awkward but not impossible. The equation would be now

$$x^2 + 2x - 68 = 10$$

and on transposing as before we would have

$$x^2 + 2x - 78 = 0$$

and the reader can try as hard as he like, but he will not find any two simple integers whose difference is 2 and whose product is 78 (for that is what the previous solution amounted to). Still we are not beaten; the mathematicians of the middle ages taught us how to get round this trouble. We apply the transposition process differently, more like the way we applied it in the first problem. Add 68 to each side and we find

$$x^2 + 2x - 68 + 68 = 10 + 68$$

or $$x^2 + 2x = 78.$$

Now add 1 to each side. Why? Because by so doing we obtain on the left-hand side an expression which is a "perfect square." Thus

$$x^2 + 2x + 1 = 79$$

But $$x^2 + 2x + 1 = (x + 1)(x + 1) = (x + 1)^2$$

Hence $$(x + 1)^2 = 79$$

and $$x + 1 = \sqrt{79}$$

so that $$x = \sqrt{79} - 1.$$

So we have found the answer, although the number to be substituted for x in order to make $x^2 + 2x - 68$ equal to 10 is not a simple integer, but an irrational number. But let us pause; when we asked for the expression to be equal to 12, we found there were *two* answers possible. Why are there not *two* now? Well, there are, for there are *two* irrational numbers whose square is 79, *viz.* $+\sqrt{79}$ and $-\sqrt{79}$, and so when we found that

$$(x + 1)^2 = 79$$

we could write

$$x + 1 = -\sqrt{79}$$

as a possibility just as much as

$$x + 1 = +\sqrt{79}.$$

Obviously x cannot be chosen to satisfy both these demands at once, but if we make x equal to $-\sqrt{79} - 1$, it will make $x^2 + 2x - 68$ equal to 12, just as much as putting $+\sqrt{79} - 1$ for x.

This second method, technically called "completing the square," is always applicable in the case of any quadratic expression. Let us give another example. Suppose we want to make $x^2 + 6x + 12$ equal to 6, what value of x will do? Write down the equation

$$x^2 + 6x + 12 = 6.$$

Subtract 12 from each side

$$x^2 + 6x = 6 - 12 = -6.$$

Now add 9 to each side

$$x^2 + 6x + 9 = -6 + 9 = 3.$$

The addition of 9 was made as before so as to produce a perfect square on the left side; for $x^2 + 6x + 9 = (x + 3)(x + 3)$ or $(x + 3)^2$.

Thus $\quad (x + 3)^2 = 3$

and so either $\quad x + 3 = +\sqrt{3}$

or $\quad x + 3 = -\sqrt{3}$

and therefore $\quad x = +\sqrt{3} - 3$

or $\quad x = -\sqrt{3} - 3.$

Two irrational answers arise as before, but still *two* answers, and that is a general feature of all "quadratic equations."

In order to bring out a feature of the relation of these equations to problems about actual things and not about abstract numbers, let us consider the following "puzzle" as we might call it. "A number of posts is set up in a space of 40 yards at equal distances. Had there been 2 posts more, the gap between two adjacent ones would have been reduced by 1 yard. How many posts are there?" Suppose the number of such gaps is x at first, so that there are in fact $x + 1$ posts. Then the distance between neighbours is $40/x$ yards. We are told that if there are $x + 3$ posts and therefore $x + 2$ gaps, the distance between neighbours is $40/x - 1$ yards. If that is so, the whole length must be

$$(x + 2)\left(\frac{40}{x} - 1\right) \text{ yards.}$$

But this is 40 yards. Therefore we have our equation

$$(x + 2)\left(\frac{40}{x} - 1\right) = 40.$$

Use the distributive principle to work out the left side. Thus

$$(x + 2)\left(\frac{40}{x} - 1\right) = x \times \frac{40}{x} - x + 2 \times \frac{40}{x} - 2$$

$$= 40 - x + \frac{80}{x} - 2$$

$$= 38 - x + \frac{80}{x}$$

Hence

$$38 - x + \frac{80}{x} = 40.$$

Logic gives us $$-x + \frac{80}{x} = 2.$$

But that multiplying equals by equals gives equals is likewise logical; so multiply each side by x. The left side becomes $x\left(-x + \frac{80}{x}\right)$ and the right side, $2x$.
Distribute the left side once more and we obtain $-x^2 + 80$ from it, and so

$$-x^2 + 80 = 2x.$$

Add x to each side and by logic

$$80 = 2x + x^2.$$

But this is just the equation we worked out a moment ago. It has two "roots" (as they are called), namely, $+8$ and -10; *i.e.* either of these values, if substituted for x, will satisfy the equation. But clearly the second one is no good to us *for our problem*; we cannot have minus 10 gaps and minus 9 posts; however, the first root is all right, 8 gaps, *i.e.* 6 posts, will work, as the reader can easily show.

Now this is really an important point. When we are dealing with a problem about the counting of real things, our answer must be in those numbers *with which we can count*, *i.e.* the *positive* integers. So when we reduce our problem to an equation, if no root of the equation is such a number we have shown that the problem is impossible *about real things*; but the equation is still possible for the abstract numbers of the mathematician, which include negative and irrational numbers, and, paradoxical as it may seem, an enormous amount of his work, not only of intense interest to himself but of great practical service to scientists, engineers and others, would be impossible without such equations. Nay, more, we can, to conclude this chapter, give the reader an example of a still more apparently ridiculous kind of number. Suppose we asked for a value of x which would make the expression $x^2 + 10x + 30$ equal to 4. The equation is

$$x^2 + 10x + 30 = 4$$

leading to $$x^2 + 10x = 4 - 30.$$

We complete the square by adding 25 (which is the square of 5, 5 being the half of 10). Thus

$$x^2 + 10x + 25 = -26 + 25 = -1$$

or $$(x + 5)^2 = -1.$$

So $x + 5$ must be equal to the square root of *minus one*! "Now this *is* arrant rubbish," the reader possibly exclaims, "if you ask me to believe that any numbers when squared give a minus result. That a positive number when multiplied by itself gives a positive result I have always known, and you have been most careful to insist that if I multiply a negative number by itself, that is also positive." Quite so; that is perfectly true about the numbers *we have so far defined*, integers, fractions,

irrationals, positive or negative. There is no use throwing up the reproach that the square root of minus one is a number we "can't count with." Irrationals are of no use for that. Actually the mathematician "invents" (for that is really what he does) a whole host of new numbers, which he *defines* to be such that their squares are -1, -2, -3, -4, or indeed minus any of the positive numbers, rational or irrational, previously defined. His former numbers he groups under one title —"real." These new numbers he calls "imaginary." Once more his own curiosity and ingenuity enable him to work out a host of interesting properties which they possess, and although of course they are of no use for "counting" (being in no worse plight than the irrationals in that connection) it is a fact, perhaps astonishing to the reader but none the less true, that many practical conclusions deduced by him for the scientist and engineer would be much more difficult to work out without these "imaginaries." For instance every electrical engineer, studying the derivation of the formulæ used in connection with alternating current machinery, must be familiar with these peculiar but exceedingly useful numbers.

In short, numbers are abstract entities only limited by the definitions we impose on them. After all, "definition" is only another word for limiting.

It should be mentioned that when we equate a cubic or quartic expression to any number we obtain cubic and quartic equations. These are always soluble provided we admit irrational and imaginary answers as valid whenever they turn up. There are always three roots for a cubic equation, and four roots for a quartic. Similar statements are true for equations of still higher "degree," but they involve methods of solution which are extremely complicated and only few mathematicians of the very "advanced" order pursue the "Theory of Equations," as this branch of Algebra is called, to such ultimate stages.

The reader may have heard of "logarithms" and "slide rules" as practical means for carrying out otherwise tedious calculations with ease and expedition. He may therefore be interested to read a word or two about the "nonsensical" notion (for so he will think at the first glance) upon which these are founded. We know what 2^2, 2^3, 5^2, 5^4, . . . mean; the last one is, as he would say, "Four fives multiplied together." "What then is $5^{\frac{1}{2}}$?" Five multiplied by itself a half times ! ! Consider these few results

$$5^2 \times 5^3 = 5^5$$
$$5^4 \times 5^3 = 5^7$$
$$5^6 \times 5^4 = 5^{10}$$

and so on.

Note that the index on the right is always the *sum* of those on the left; for when you multiply, for example, 5^4 by 5^3, the number of fives involved is 7. Well then it is obviously true that

$$5^1 \times 5^1 = 5^2$$
$$5^2 \times 5^2 = 5^4$$
$$5^3 \times 5^3 = 5^6.$$

Suppose we *agree* that $5^{\frac{1}{2}}$ shall obey the same rule; then

$$5^{\frac{1}{2}} \times 5^{\frac{1}{2}} = 5^1$$

for the sum of $\frac{1}{2}$ and $\frac{1}{2}$ is 1, So $5^{\frac{1}{2}}$, *by our agreement that the law of indices is to be general*, turns out to be $\sqrt{5}$, the square root of 5. Similarly $5^{\frac{1}{3}}$ is the cube root of 5, $5^{\frac{1}{4}}$ the fourth root and so on. We can go further and give a meaning to a negative index. It turns out that 5^{-2} is the result of dividing 5^2 into unity; it is $1/5^2$, 5^{-3} is $1/5^3$, and so on.

Here then is a further example of the mathematician widening his powers by generalising his definitions; and as already stated, quite apart from his own pleasure and interest in the new extensions of his methods, every table of logarithms and every slide rule used by practical calculators depend on this new extension.

In this way Algebra, which came on the scene as generalised Arithmetic, gradually took on a character of its own. As in Arithmetic the notion of number was separated from any association with any particular set of objects, so in Algebra the notion of number was even further refined so as to be abstracted from reference to any particular numbers. Just as a number like 7 refers impartially to any group of seven objects, so in Algebra a letter like a or x is used to refer impartially to any number, on the understanding of course that each letter in any particular problem, or in any particular analysis of a particular expression, must refer to the same number throughout. Analysis of expressions, such as those suggested above, and many other types, some of incredible complexity, gradually led to the notion of " variable " and " functionality," and the reader will realise that the idea of functionality is the mathematical counterpart of the well-established order of nature expressed in the experimentally discovered laws of the physicist and chemist. Just as the value of an algebraic expression depends on the values of the variable or variables which appear on it, so does a physical quantity (like a gravitational force, for instance) depend on other physical magnitudes with which it is related by observation (distance apart and masses of the gravitating bodies, for instance). Without such mathematical expressions and the technical means of manipulating them invented by the mathematician *for their own sake*, mathematically expressed laws of nature, which came on the scene in the seventeenth century and have since multiplied in number and importance, would have been a sheer impossibility.

GEOMETRY

Our external world is a world of form, colour and sound. The forms of visible objects are infinite in their variety, and frequently the form of even one body will change under the action of wind or other natural causes in a most varied manner. The study of the fundamental laws of shape has always been an absorbing pursuit for the mathematician. The Greek philosophers were attracted to this study, in which they showed pre-eminent genius, when they became acquainted with the rules of mensuration and land-surveying discovered by the Egyptians. Although they gave the name " Geometry " to this study, thus acknowledging the source from which the impulse came, they regarded mere " earth-measuring," as compared with the true science of Geometry, in much the same light as they regarded mere calculation in comparison with Arithmetic or a true science of numbers. Mensuration was an art useful no

doubt in practical life, but no substitute for the study of Geometry in the eyes of the cultivated man.

When we look at any ordinary object such as a stone we see that it has a surface. The stone itself is "extended in space." We say it is extended, or has extension, in three dimensions, meaning that every body can be considered as divided into parts, the majority of which, apart possibly from parts near its surface, can be conceived to be of the rectangular block shape, and about such a block *three* statements have to be made before its size and shape are given, *viz.*, statements about the magnitude of its length, breadth and height. But the surface is not extended in quite the same way. If we put the point of a pin in contact with the stone, we say that the point is "on the surface of the stone"; but a little thought will show that it is just as correct to say that the point is on the surface of the air which lies around the stone; in short the surface belongs to the air as much as to the stone; it separates the air from the stone; it really "contains" neither stone nor air. Look at this in another way. Move a pencil downward from air into water; we can be quite sure when the "point of the pencil," meaning the little tip of graphite at its end, is entirely in the air, and when entirely in the water. We recognise, however, that there is a short interval during which it is partly in air, partly in water. We may say in colloquial language that it is then on the surface of the water; but this is absolutely incorrect in strict geometrical language. A body extended in three dimensions, however small, *cannot be contained in a surface*. It is clear that in introducing the notion of surface we have embarked on another adventure of abstraction, of a different type from that employed when we begin to deal with number. The surface is extended only in two dimensions. A common error is to regard a sheet of paper as a surface; a sheet of paper is a rectangular *solid* just like a block of wood. I measure the thickness of a book apart from its binding and I find it to be one inch; there are 300 pages in the book; so each page has a thickness of 1/300 inch, and there are specimens of paper thinner than this. But any fraction of an inch, however small, is not *nothing* in magnitude. So a sheet of paper has six faces just like any other rectangular solid, although four of its faces are rectangles in which a pair of sides have a very tiny length.

Let us take another glance at a block of wood; its surface (or to be quite accurate the surface between the wood and the surrounding air—but we will not be pedantic in future so as to avoid long phrases) has six parts; we call them "faces." These faces cut each other at the edges of the blocks; each edge is common to two faces and, by reason of this property, is extended one dimension less than a surface; it is extended only in one dimension, or, as the text-book has it, it has length, without breadth or thickness. Notice that this is not true of a thread or wire, however thin. All actual bodies are extended in the full three dimensions. It is not even true of the graphite strokes which we make on paper with a lead pencil and call "lines." A line in the strict geometrical sense is the result of a double abstraction carried out on actual matter; while the stroke on paper has obviously a breadth (or it would not be seen) and has a depth also, being in fact a very shallow ridge of graphite lying on the page. Even the printed letters on this page have some depth. Actually,

edges of blocks are frequently blunt or rounded enough to be obviously lacking in the strict characteristics of a true geometrical line, and even the sharpest edge has just sufficient bluntness to show that a line is really an abstraction from the external characters of real bodies.

There is still another abstraction to be made and we reach the idea of "point." Edges of blocks meet in corners; a corner is common to two edges; and so, although in actual fact it is not strictly a point in the genuine sense by reason of some amount of bluntness however sharp it may feel, the corner gives us the idea of two strict geometric lines crossing and having as a common element a point, an entity which may be said to be in a definite place but is not extended in any dimension at all; "it has position but no parts"; or it has position but neither length, breadth nor thickness; or, briefly, it has position but no size.

Now points, lines and surfaces are the abstractions with which Geometry is concerned; with these and certain axioms and definitions about them it proceeds to build up a wonderful science of form, unfolding gradually by processes of pure thought an amazingly complicated structure of propositions or "theorems," to whose number there appears to be no limit save that set by pure exhaustion of human interest.

The great Greek mathematician Euclid, who lived about the beginning of the third century B.C., made a famous collection of geometrical theorems and problems known in his time; he arranged them in a logical order so that each proposition could be deduced from previous propositions. This work in thirteen books, copied many times (and in later ages printed for many publishers), edited and commented on by many great scholars, has remained until quite recent years the only text-book for pupils desiring to understand Geometry. So universal was this practice that "Euclid's *Elements*" (often abbreviated simply to "Euclid") was a recognised synonym for "Geometry." Many of the editors added additional propositions and submitted to the reader lists of further theorems on which to try his skill (such theorems are often called "riders"), but with few exceptions the arrangement and methods of proof adopted by Euclid were unaltered, apart from the introduction here and there of certain simpler ways of phrasing sentences.

Euclid begins by making certain statements which he calls *definitions, postulates* and *common notions*. The definitions refer to the abstract material mentioned above, namely points, lines and planes; to figures such as squares, rectangles, triangles, etc., which can be constructed with lines; to other figures such as circles, and in the later books to solid figures such as cubes, pyramids, spheres, etc.. The postulates refer to certain operations which he assumes to be allowable, or to certain geometrical statements which he cannot prove but considers to be evident without proof. *E.g.*, he postulates that a *straight line* can be drawn from any one point to any other; he also postulates that although an infinity of different lines can join two given points, *only one of these is straight* or, what comes to the same thing, two straight lines cannot enclose an area. The reader's attention is drawn to this. Everyone has intuitive, practical notions of straightness; tight threads, edges of rulers, sighting along marks, etc., are illustrations of these practical notions; but a straight line cannot

be defined in a strict theoretical sense. Any such definition is simply a verbal phrase involving words and ideas as undefinable as straightness itself. It is in these postulates of Euclid that we find those properties of straight lines which are necessary and sufficient for the proofs of subsequent propositions. Another postulate requires us to admit that a circle may be described with its centre at any given point, and its circumference at a given distance from that point. This implies the use of compasses, but it should be carefully noted that although in one of the earlier postulates Euclid assumes that we can join two points by a straight line, thus implying the use of a ruler, he *does not assume that the ruler is graduated by marks into equal divisions*. The reader may have heard the statement that although we can bisect any angle " by Euclid," we cannot trisect it, and may have thought that there was some mystery surrounding the denial of an operation which is so palpably possible, say with a protractor. But he is reminded that the impossibility is dependent on the conditions postulated by Euclid. With a graduated ruler the process is possible, in fact not at all difficult; but it cannot be achieved if we limit ourselves to the only instruments whose use is postulated by Euclid, that is to say, a pair of compasses and an *ungraduated* ruler.

There is another famous postulate about parallel straight lines, but we shall leave that for a moment and consider some of the statements which Euclid calls " common notions." In using this phrase Euclid was following the lead of Aristotle, who suggested the use of this term instead of " axiom." The word " axiom " (a statement worthy of belief), however, has persisted and is in common use in all the editions of Euclid now extant. To be sure, Aristotle was very precise in the meaning he attached to " axiom "; according to him, it should only be used for statements of a general nature, not geometrical, which we assume to be true; when geometrical statements are made the correct name for them should be postulate, or definition, or common notion. Thus of the following two axioms or common notions of Euclid, only the latter would be a true axiom according to Aristotle. " Things which coincide when applied to one another are equal to one another." " The whole is greater than the part." The former statement he would have classed as a definition of geometric equality, or perhaps postulate. Here are some axioms :—" If two or more magnitudes are equal to the same magnitude they are equal to each other " and " If equal magnitudes are added to other equal magnitudes the sums are equal." There has been, however, in the past a certain amount of variation in the use of the words " postulate " and " axiom "; thus the parallel postulate, to which we referred above and which will be discussed presently, is more frequently referred to as the axiom of parallelism.

The propositions of Book I. of the *Elements* fall into three groups. The first group deals with triangles, and intersecting straight lines and the angles between them; in these the concept of parallelism is not required. The second group introduces the idea of parallelism by means of the famous postulate referred to above. There is a good deal of misconception about this idea, and so we shall consider Euclid's treatment of it and some modern modifications, since they have a very important bearing on our ideas about the nature of the physical space in which we observe

all our phenomena of position and motion. Among the first group of propositions in Book I. there is one in which he proves that any two angles of a triangle make up less than two right angles. So if two straight lines in a given plane cross a third straight line at B and C and themselves intersect at A the angles marked I and II in the figure, when added together, are less than two right angles (Fig. 2).

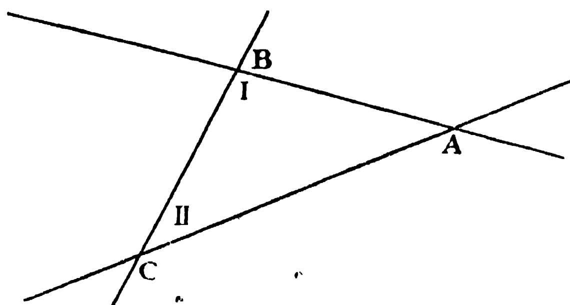


FIG. 2

Now suppose that the two lines cross the third line at B and C and make the two angles marked I and II together equal to two right angles (Fig. 3), then the lines do not meet, at all events on the right hand side. This can be

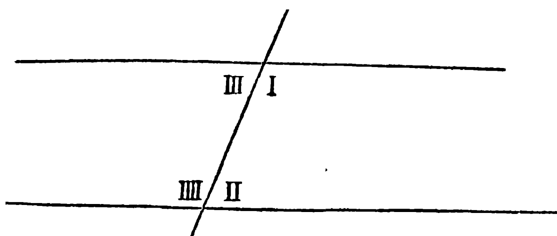


FIG. 3

proved by the so-called method of *reductio ad absurdum* (reduction to an absurd conclusion). For if the lines are assumed to meet on this side then by the earlier proposition I and II are together less than two right angles, which is a conclusion contradicting the hypothesis that they make up two right angles. Moreover, since it can be shown from earlier propositions that if I and II together make up two right angles, then the angles marked III and IV do likewise, it follows that the lines do not meet on the left-hand side.

Now comes the critical point. Consider a line marked XY in the figure and a point marked B (Fig. 4). We see that there is at all events *one* line

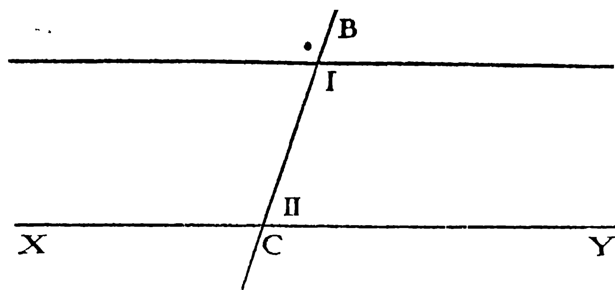


FIG. 4

through B (in the plane of B and XY of course) which does not meet XY anywhere, no matter how far extended in either direction. It is a line so drawn as to make the angles marked I and II together equal to two right angles, where BC is any line drawn to cut XY. The question is, Are there any other lines in the plane through B than this one which enjoy the same property; *i.e.*, is there *only one* line through B in the plane which does not cut XY anywhere? Now the reader must put all *intuitive* notions, based on hedgerows running side by side along very straight roads, or on railway lines or like objects, sternly out of his mind. The argument is not about *material objects* at all, but about creations of the mind abstracted from such material objects. In the nature of things, obviously, no one can prolong such objects to any length he likes; such prolongation as can be effected is not even "in a plane," but on the curved surface of the earth.

Now on this question, Euclid postulated that there is only one parallel line through B, *i.e.*, only one line which does not intersect XY anywhere.

He phrased his postulate thus:—"If a straight line meeting two other straight lines makes the two interior angles on one side of it together less than two right angles, the two lines are *not* parallel; but can be made by production to meet on the side on which are the two angles less than two right angles." This clearly denies the property of parallelism to any line through B, except the one which makes the sum of the two interior angles (the angles marked I and II in Fig. 4) equal to two right angles; but the reader must carefully note that Euclid had to *postulate* it; he could not *prove* it from his earlier axioms, postulates and theorems. Since his own time mathematicians in all ages have felt that the situation was not satisfactory and have made ingenious attempts to prove this famous postulate, but to no avail; it has always appeared on rigorous investigation that the supposed proof concealed an assumption which was tantamount to Euclid's own postulate. An interesting feature of the situation is the fact, already stated, that at an earlier stage in his first book Euclid proves quite satisfactorily (and of course before he refers to parallel lines at all) that two angles of any triangle are together less than two right angles, from which it follows as an obvious result that if two lines are drawn to cut XY

and if they meet, then the two interior angles on that side are together less than two right angles. Thus Euclid's postulate is the " converse " proposition to this earlier theorem ; *i.e.*, a proposition in which what is stated as the conclusion in the other proposition is now stated as the hypothesis, and what is stated as hypothesis in the other proposition is now stated as the conclusion. The unsophisticated reader may naturally think that it should be all right and that if we can prove a proposition to be true, we have *ipso facto* proved the converse proposition to be true. But that is not so. After all, geometrical reasoning uses the propositions of Logic, as well as the special postulates and proved propositions of Geometry itself, and the Logicians can easily confute the facile assumption that a proposition and its converse must *of necessity* both be true. It may be so, but not *of necessity*. The converse proposition must be as rigorously investigated as the one to which it is converse. For example, " If an object is red, it is not black," is true ; but " If an object is not black, it is red," is not necessarily true.

In any case Euclid proceeds on the basis of the assumption that there is only one parallel line in the circumstances mentioned above. He then deduces a few simple properties of parallel lines and proves the well-known theorem that the sum of the three angles in any plane triangle is equal to two right angles. (We shall return to this theorem a little later.) There follow an important series of propositions about parallelograms, or four-sided figures, whose opposite sides are parallel. Thus it is proved that parallelograms on the same base, or on equal bases, and between the same parallel lines are equal in area. (In Fig. 5 the parallelogram

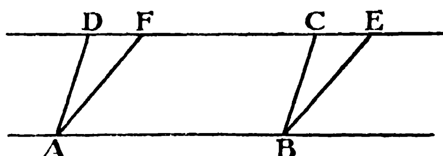


FIG. 5

ABCD is equal in area to the parallelogram ABEF. In Fig. 6 the parallelogram ABCD is equal in area to the parallelogram EFGH, if AB = EF)

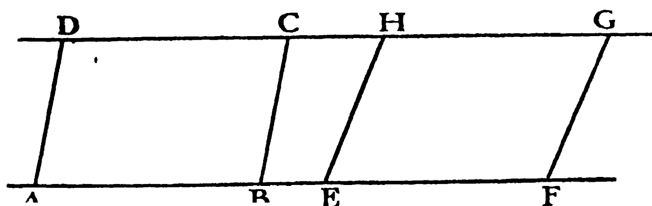


FIG. 6

It is very instructive to note that the treatment here is not *arithmetical* ; *i.e.*, we are not engaged in mensuration. Naturally the reader may wonder how we can treat of equality of areas without " multiplying a length by a

breadth" ; and if we multiply, surely arithmetical operations are involved. But if he reflects that an *ungraduated* ruler and compasses are the only tools supposed to be available, *measurement* of a length or breadth in any units is out of the question. The truth is that Euclid bases all statements of equality of area on notions of "congruency," or the perfect fitting of figures. Earlier in his first book he deals with triangles which have sides or angles equal in such number as to fit perfectly if superposed one on the other. Thus, looking at Fig. 5, it appears from the propositions proved about parallel lines that the triangle ADF is congruent to the triangle BCE ; the former would fit the latter perfectly if " slid over " on to the latter. So the area of the triangle ADF is equal to the area of the triangle BCE, and it is then obvious why one parallelogram has an area equal to the other, without any reference to measurement of length and breadth. A similar type of proof suffices for the other proposition. Note that the statement that AB and EF are equal in length only requires the use of compasses. To proceed, the remainder of the first book continues to deal with areas of figures, especially with the equality in area of triangles on the same base or on equal bases, and between the same parallel lines. Again it should be noted that mensuration and arithmetical operations on numbers are not involved, and that the whole validity of his procedure is based on the assumed truth of his parallel postulate. The first book closes with a beautiful proof of the famous theorem, discovered two centuries earlier by Pythagoras, concerning the squares on the sides of a right-angled triangle. This proof is probably Euclid's own.

The second book deals with some important propositions about the areas of rectangles. Each of these is an analogue of an important proposition in Algebra, and probably nothing will give the reader a clearer conception of the different spirit in these two abstract sciences, Geometry and Algebra, than a reference to one of these propositions.

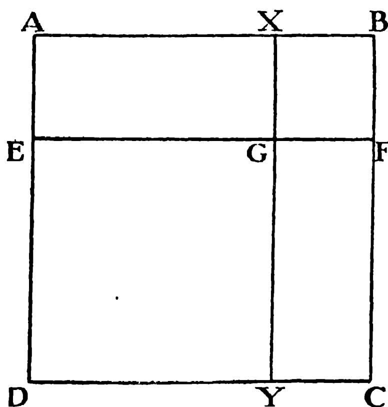


FIG. 7

Divide the line AB at any point X into two parts. Construct the square ABCD and the square XBFG. Complete the figure as shown, and it is

not difficult to prove in the *pure geometrical* manner that the square on AB is equal in area to the sum of the areas of the squares on AX and XB and of twice the area of the rectangle contained by sides equal to AX and XB. (The figure itself almost shows it intuitively without the formal steps in the argument.) The analogous proposition in Algebra is mentioned in the previous chapter, namely:

$$(a + b)^2 = a^2 + b^2 + 2ab$$

as is obvious, if we suppose AX and XB, measured by a *graduated* ruler, to be a inches and b inches respectively and the ordinary mensurational rules applied.

The third and fourth books deal with the general properties of circles and of certain rectilinear figures which can be inscribed in a circle, or circumscribed so that all the sides touch a circle. The fifth book is one of the most subtle chains of reasoning known to man, dealing with the connection between number and magnitude, and the conception of ratio, *but entirely independent of the arithmetical operation of division.* It is generally regarded as one of the most difficult books in the *Elements* to follow, and in most modern editions considerable changes are made in the presentation so as to render the study of it a simpler matter for the tyro. The modifications introduced by the famous nineteenth century mathematician, de Morgan, are frequently adopted. The propositions of the fifth book are really necessary in order to deal satisfactorily with the geometry of similar figures which bulks large in the sixth book.

In these six books Euclid deals with the geometry of figures in a plane. Later in the eleventh, twelfth and thirteenth books he deals with the geometry of solid figures in three-dimensional space, treating the properties of cubes, prisms, pyramids, spheres, etc., in an analogous manner to that used for the plane figures and, in particular, treating the volumes of figures, without appeal to mensurational rules based on measurements of length, height and breadth. The books between the sixth and the eleventh are largely concerned with propositions of an arithmetical and algebraic nature, and are usually omitted in the printing of modern editions of the *Elements*.

In order once more to emphasise the abstract nature of Geometry let us recur to the question of parallelism. From Euclid's postulate we can prove that the sum of three angles of a triangle is equal to two right angles. Now is this really true of any plane triangle having its three corners at points in our physical space? No doubt careful drawing and measurement on a large sheet of paper reveals no discrepancy that cannot be put down to lack of precision in our instruments. Every land-surveyor, every constructor of an ordnance map, uses this proposition and finds no inconsistency in his results. The astronomer uses the rule to find the distances from the Earth of Sun, Moon and planets and a few of our nearest neighbours in the stellar galaxy. But, be it noted, *only a few.* The instruments he employs are sufficiently precise to carry him to about 1,000 billion miles with any degree of confidence in his results. The immense majority of the stars in the heavens are beyond that limit, and any guesses which he makes at their distances employ certain results of Physical Science, in addition to Geometry, as a guide. In short, the geometrical result *cannot be tested*

for immense triangles. Now in the nineteenth century certain mathematicians, Gauss in Germany, Lobatschewski in Russia, and Bolyai in Hungary, gave up the attempt to prove Euclid's postulate and proceeded to deduce what would be true if there were other lines through a given point than the one considered by Euclid which are parallel to a given line (lying in the same plane, of course). A perfectly consistent Geometry is the result, but one in which certain conclusions differing from those in Euclid's *Elements* are deduced. For example, in this Geometry the three angles of a triangle are together less than two right angles and the defect of the sum under two right angles grows larger and larger as the size of the triangle increases. There is also a system of Geometry due to a German mathematician Riemann, which postulates that to any given line there exists no parallel line at all, that any line in the same plane must meet it somewhere. This Geometry, as a matter of fact, begins altering Euclid's postulates at an earlier stage than the parallel postulate so as to invalidate his proposition that the sum of two angles of any triangle must be less than two right angles. With his system of postulates Riemann could deduce that the three angles of a triangle are together greater than two right angles of a triangle, the excess growing larger as the size of the triangle increases.

Turn for a moment to another proposition, the Pythagorean theorem concerning a right-angled triangle. The proof of this is also dependent on acceptance of Euclid's parallel postulate. Without this the theorem cannot be deduced. Now this theorem forms the basis of a whole series of mensurational formulæ which are in daily use for many practical purposes and lead to no inconsistency. To be sure the theorem is not true in its simple form for an extended triangle drawn on the Earth's surface, but of course such a triangle is not a *plane* triangle, and in any case the mathematician can deduce from the assumed truth of the theorem for a triangle in a plane, what modifications must be introduced into the surveyor's and the navigator's formulæ in order to render them theoretically valid and therefore presumably correct in practice. Yet there remains the question of interest to the scientist and philosopher, if not the practical man—is the theorem really valid in our physical space? As far as we can judge, for relatively small plane triangles it is practically true, but does the validity extend to enormous triangles? In fact the situation is similar to that in which the theorem about the three angles of a triangle finds itself on strict scrutiny, and again the conclusion is inevitable; if the parallel postulate of Euclid is abandoned and another postulate replaces it, the usual statement concerning a plane right-angled triangle will not be true and another result will take its place, of a rather more complicated nature, concerning whose exact form we cannot speak now.

Clearly the situation calls for the *experimenter*, physicist or astronomer, and it takes no elaborate argument to convince one that the problem is beset with many difficulties of a theoretical as well as a practical nature. True the practical man, satisfied with the well-tried accuracy of his conclusions on the surface of the Earth, and hearing that after all if there are any discrepancies to be found when the astronomer plumbs the depths of our physical space they are minute, may shrug his shoulders at the manner in which men of a different temperament worry themselves over

"trifles." But to the scientist and philosopher this is no trifle. Philosophy faces many problems concerning man's nature, but one of its oldest tasks and one which has engaged the minds of some of the greatest thinkers, is just the nature of our physical space and time, and in connection with that these geometrical results which we have been discussing play a vital part. To clear away any possible misconception on the part of the reader concerning the exact nature of the dilemma, we must warn him that there is no question of Euclid being "wrong." Our space may very well be "non-Euclidean"; but that does not affect the question of the correctness and consistency of Euclid's propositions as logically and systematically developed by him *from his axioms and postulates*. As an exercise in reasoning on *abstract* entities such as points, lines and planes, etc., his Geometry is perfectly valid. Whether there exist in our physical space any *material* entities enjoying the properties deduced for points, lines, etc., is a matter for the experimental scientist; it is of no interest to the mathematician as such. The fact that his deductions do in fact have a close relation with actual things is a fortunate circumstance and one which is of tremendous importance to man as accountant, builder, engineer, physicist or astronomer; but it is all one to the "pure mathematician" whether his conclusions have a practical application or not.

Howbeit, although it digresses for a moment from our true purpose in this article (which is to analyse and describe the purely mathematical processes of the reasoning mind), the reader will possibly be interested to know how matters stand with regard to the scientific problem just indicated. The most serious difficulty of a practical nature facing the experimentalist is that all the bodies in our space whose observable geometrical relations are under investigation, are not at rest but in relative motion to one another. (After all, in the purely mathematical consideration of a geometrical problem the configuration of the points, lines, etc., in the figure remain unchanged.) This would not be so troublesome a feature if one perceived the bodies in the same places as they actually occupy at the moment of perception; but this is not so. When we look at the Sun we see it to be where it was some eight minutes earlier, because it takes eight minutes for light to travel from Sun to Earth. Furthermore, because of the different distances from us, the lag of time between the location of a body in a place and the perception of that location varies from body to body. The problem has in very recent years been placed on an entirely new basis by the discovery that the behaviour of light does not copy in detail the motions of bodies or of waves in deformable media (views prevalent in the previous century or two). On the basis of this newly ascertained *experimental* fact, Einstein has laid down a certain broad principle concerning the nature of our scientific laws (it is known as the Principle of Relativity) and has, for the scientist at all events, simplified the position, although there is a very prevalent, but quite unjustifiable, idea to the contrary. This principle has led to certain conclusions concerning the "metrics" of our space, meaning by that the measurable relations connecting observable bodies, and these have been extended to include such great stretches of physical phenomena as are embraced in the terms "gravitation" and "electromagnetism." One of the most unexpected results, evoking the unbounded admiration of those trained to

follow the argument, is that, on considering quite dispassionately certain properties of that ultimate particle of matter which we call an "electron," we are almost forced to conclude that our physical space is *finite in size*. There is no paradox about this although, on hearing of such an idea for the first time, an unsophisticated man probably enquires, What is the nature of the "boundary" or "wall" which limits its size? But a moment's reflection shows us that there need be no boundary; the surface of the earth is finite in size yet there are no boundaries; we can, apart from physical difficulties of transport over mountains and polar wastes, go round it in multitudes of different paths. We naturally feel at the first blush that this analogy is not quite sound; we can *conceive* in a direct, intuitive way how the earth's surface may be finite and yet "unbounded,"[1] because we have *direct perception* of such things as oranges, balls, etc. No such direct intuition is available to us in the case of "finite but unbounded space." Yet the inference that it is so is quite as definitely based on observable experimental results as the conclusion about the earth's surface. Putting it quite definitely, if somewhat crudely, the physicist and astronomer believe, on what they regard as perfectly irrefutable evidence, that if a being could somehow ferry himself across space and survive for an enormous number of years, and always continue along what he *would believe to be a straight line*, he would in time arrive somewhere near his starting-place. (We often talk about going "in one direction" on the Earth; but of course the mariner steering "dead straight" on his shortest course from one place to another travels not along a straight line but along a "great circle" of the Earth's surface.) The physicist also makes a shot at what the length of his journey would be—ten thousand trillions (10^{22}) of kilometres!! The mind shrinks, appalled, at such a figure, yet it is not *infinite*.

If this be so, we have an answer at once to the question, Is Euclidean Geometry valid in our space?—and it is "*No!*" This is what is meant when one reads nowadays about "curved" space. The use of that phrase implies that the conclusions of Euclid's system of Geometry are not found to be true in our space. The agreement observed in our terrestrial measurements, or in regions not too far extended from the Earth, rests on the restricted nature of such observations, just as a small sheet of water on the Earth appears flat while the ocean is obviously curved.

Even before the advent of the Relativity Principle, there were certain considerations of a more speculative character which pointed to a similar conclusion. If one assumes our space to be infinite in extent, we must ask ourselves if it is in all its extent populated with galaxies of stars similar to those which we know to exist relatively near to us. Now the answer to such a question raises serious difficulties for the notion of infinite space. Suppose, for example, we admit that the stars are not "innumerable," *i.e.*, not really infinite in number, nor greater than some conceivable number. Then there is a finite number of them. We can conceive that they are distributed, in much the same way as the stars we know, in some finite portion of space—enormous no doubt, but still finite and

[1] There is a poetical use of the word "unbounded" which makes it practically synonymous with "infinite." That is not intended here; it is used with its true meaning—"having no boundaries."

therefore *as nothing* compared to infinite space. This state of affairs cannot last; in time, as can be readily shown from statistical considerations and the ordinary laws of motion, the stars will gradually spread themselves, becoming less and less densely distributed in space, until after the lapse of a time, enormous no doubt, but *finite*, any small group of stars like our solar system would find itself without a neighbouring star within sight. Now, philosophically, we have no less reason for postulating infinite time than we have for postulating infinite space, with the result that we find it difficult to account for the fact that we here and now obviously have very many neighbours in the heavens.

If, on the other hand, we agree to regard the stars as really infinite in number, and any part of space, however distant from us, as inhabited by galaxies like our own, we are in no better case. The laws of gravitation and light propagation, as discovered by the physicist, lead to the conclusion that at all times our heavens would be an intolerable blaze of light compared to which sunlight would be a feeble flicker, and the gravitational forces on us would be infinite in value and rend the earth into the tiniest fragments.

It is true that the full force of these conclusions could be evaded by *ad hoc* assumptions involving the existence of absorbing, partially opaque matter in space and small modifications in Newton's law of gravitation. But, as already indicated, Einstein's great principle, with its amazing result concerning a connection between the size of our Universe and the electrical theory of matter, has clinched the argument.[1]

It is time to return to our study of purely mathematical reasoning.

LIMITS: THE CALCULUS: PERIODICITY

Mathematics based on abstraction of number and form is admirably suited to the symbolic representation of a static world; but to take account of the flux of events a further element is needed. The discovery of this was a modern achievement, though the germ of the method may be found in the work of Archimedes, the famous Greek mathematician who lived in the third century B.C. The poverty of symbolic methods in his day, however, prevented its growth, and not until the development of algebraic symbolism in the sixteenth and seventeenth centuries could the conception of "fluxions" be embodied in a specific notation, which is due in part to Newton and in part to Leibniz.

The most obvious example of change in our world is motion, or change of position. A body is now in a certain position, but it is moving; it has a certain speed, we say. To give the physically essential information about the body we must state its position and its velocity of movement. The former is a matter of geometry. What about the latter? Can we really say anything about its speed *at an assigned position*? On the face of it we can apparently only refer to speed *between two positions*. These two positions are separated by a measurable distance, over which the body travels in a measurable time. We divide the distance by the size of the time interval to obtain the speed; that is the meaning of "speed," and with

[1]A further discussion of the Theory of Relativity will be found in the Articles on *The Physical Nature of the Universe*, p. 99, and *Astronomy*, p. 120.

reference to one position only this operation is clearly impossible. So the phrase "speed at an assigned place" appears to be meaningless. As a matter of fact, the logical difficulty involved in such considerations so impressed certain Greek philosophers in ancient times that they devised several ingenious paradoxes meant to prove that motion is an illusion of our senses. (The interested reader can look up an encyclopædia on the philosopher Zeno of Elea for further information.) However, modern mathematics has completely swept aside these verbal quibbles.

In order to illustrate the way in which mathematics has extricated us from this awkward situation, let us consider a very simple type of motion. If one rolls a smooth ball down a groove on an inclined board, it can be demonstrated, by modern physical apparatus, that a simple law connects the distance and time. If the body travels, say, 3 inches in the first second of motion, it will travel 12 inches in the first two seconds, 27 inches in the first three seconds, after four seconds it will be 48 inches away from its starting-point, and so on. The essence of the law lies in the fact that 12 inches is four times 3 inches and 4 is the square of 2; 27 inches is nine times 3 inches and 9 is the square of 3; 48 inches is sixteen times 3 inches and 16 is the square of 4. One may tilt the board to different inclinations without varying the essential physical fact embodied in this "square law." Thus at a somewhat greater inclination the ball might roll 5 inches in the first second; it would then roll 20 inches in the first two seconds, 45 inches in the first three, and so on.

Naturally we cannot actually observe the ball at *any* instant; our moments of observation are limited in number and separated by discrete intervals of time, which are shorter no doubt if we devise ingenious timepieces, but cannot be indefinitely reduced in size. We now make a new kind of abstraction from the facts. We assume that what we have observed to be true for a limited group of positions and instants is true for *any* instant and its corresponding position. We invoke the "Principle of Continuity" in natural events, and embody our observations and the assumption in the phrase :—"the distance varies as the square of the time." We can, however, embody them much more succinctly in an algebraic formula. Represent the distance covered in one second from the start by a inches; then the distance covered by the ball in x seconds from the start is ax^2 inches. Note that x may be any number of seconds we like, integral or fractional. (Provided of course it is not so great that the ball has rolled off the board; but even then we can conceive a very long board to be at our disposal.) The speed between two instants can now be calculated by applying well-known algebraic results. Suppose it has taken x seconds to travel to a position which we refer to as the position P; it takes a larger number of seconds, say z, to travel to a position beyond P which we refer to as Q. Thus it takes $z - x$ seconds to travel from position P to position Q; the distance between P and Q we obtain by subtracting ax^2 from az^2, the result being $az^2 - ax^2$ or $a(z^2 - x^2)$ inches. To obtain the speed from P to Q, *i.e.*, speed on the average, we divide $a(z^2 - x^2)$ inches by $(z - x)$ seconds and this is written

$$\frac{a(z^2 - x^2)}{z - x} \text{ inches per second.}$$

Now what is the speed *at* the position P. Here we meet the difficulty referred to. The position of the body at P is perfectly definite; it requires no reference to any other position of the body; it is a question of "simple location," as the philosophers call it; the body is there and nowhere else. But speed requires some reference to another position, apparently, or we seem to make nonsense of the business. We cannot talk about the speed from P to P; if we do we must make z equal to x in the formula written down above and it becomes

$$\frac{a(x^2 - x^2)}{x - x} \text{ inches per sec.}$$

$$\text{which is } \frac{0}{0} \text{ inches per sec.}$$

a perfectly meaningless operation apparently. But there is one way of escape. No matter how near Q is to P, so long as they are actually different positions, z differs from x and the formula has a meaning and can be evaluated numerically, provided numbers are assigned to z and x. Is there a limiting value to the quotient in the process as z is reduced in value nearer and nearer to x? Let us recall the simple factorisation we referred to in the section on Algebra :—

$$z^2 - x^2 = (z - x)(z + x).$$

So
$$\frac{a(z^2 - x^2)}{z - x} = \frac{a(z - x)(z + x)}{z - x}$$

and the right hand side is just $a(z + x)$ since $z - x$ in the denominator cancels the factor $z - x$ in the numerator. Now *$a(z + x)$ is not meaningless* when z is made equal to x; its value is then $a(x + x)$ or $2ax$. This then is taken as the speed of the body at P, *viz.*, $2ax$ inches per second. The point is that as we think of a position Q nearer and nearer to P, the speed from P to Q is approaching to $2ax$ inches per second closer and closer as a limit, and this limiting value gives us our correct idea of speed at P.

But now the pure mathematician steps in and says :— "It is true that this process has been suggested to us by our need to deal scientifically with the physical world; but after all this process can be applied to all sorts of functions of the variable x without any reference to material things at all. It has an interest of its own which is purely intellectual; there are definite mathematical laws which it obeys by reason of the definition of the process and our own mental make-up." Thus we can apply the process equally well to x^3 as to x^2. Let us change a variable from a value indicated by x to a value indicated by z; another variable, which is the cube of the first variable, changes in value from x^3 to z^3. The relative change in the second variable to that in the first is

$$\frac{z^3 - x^3}{z - x}.$$

This ratio has a meaning so long as z differs from x. As before it appears to have no meaning when z is equal to x, since it becomes $\frac{0}{0}$.

But again we can factorise the numerator and *one of the factors is $z - x$*.

The factors are $z - x$ and $z^2 + zx + x^2$, as the reader can easily justify. Hence :—

$$\frac{z^3 - x^3}{z - x} = \frac{(z - x)(z^2 + zx + x^2)}{(z - x)}$$

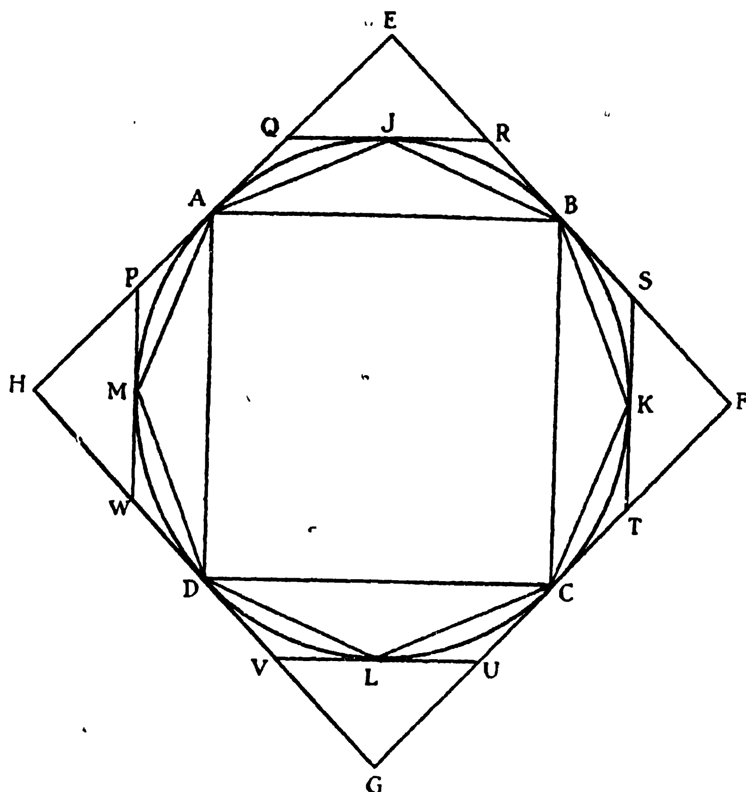
and this is just $$z^2 + zx + x^2.$$

As before just in the condition where no meaning can be attached to $(z^3 - x^3)/(z - x)$, the alternative expression $z^2 + zx + x^2$ has a perfectly precise meaning, *viz.*, $3x^2$; for on putting z equal to x we get $x^2 + xx + x^2$, *i.e.*, $3x^2$. In exactly the same way the mathematician will prove to you that this process will produce $4x^3$ from x^4, $5x^4$ from x^5, etc.; in general nx^{n-1} from x^n. He gives the process a special name, " differentiation." He calls the result a " differential coefficient." Thus the " differential coefficient " of x^2 with respect to x is $2x$; of x^3 with respect to x, $3x^2$; of x^n with respect to x, nx^{n-1}.

As may be anticipated, the mathematician finds that this process of differentiation can be applied to the most complicated functions of a variable. He has invented a special notation and symbolism for it. A very wide literature on the " Differential Calculus " has come into being in the last three centuries, embracing extremely exhaustive and very subtle discussions on the validity of the process in special cases, and an amazing number of purely intellectual problems meant to test the skill and ingenuity of the learner. More than that, just as this calculus sprang from the needs of the physicist, so in its most highly developed form it has returned to him, giving him an amazing power in the mathematical treatment of his observed phenomena. Without it he would be helpless in the face of the ever changing conditions of our world; he would be powerless to work out the quantitative aspect of these phenomena; indeed he would be without the means to formulate his laws in their most general significance. We hear of the " equations of motion," the " equations of the electromagnetic field," the " equations of gravitation," the " equations of wave propagation " and so on. Now the reader should know that these are not equations of the simple type referred to in the section on Algebra, they are " differential equations," *i.e.*, equations connecting the differential coefficients of symbols representing various physical quantities with respect to variables on which they depend, such as time and " co-ordinates of position "—" co-ordinate " is the name given to any measure of length or angle which helps to define where a point is situated with reference to a standard point of reference or " origin."

Nor is this the only aspect of those processes in Mathematics which " work to a limit." We have seen in the section on Geometry how Euclid treated distance apart of two points without introducing a *graduated* ruler as part of his postulated appliances. He was not a " mensurator," but a geometer. Now how could we treat the length along a curved line between two points marked on it in a similar way? The natural impulse is to seize a thread; lay it as carefully as possible along the curve, lift it, stretch it out and place it so tightened beside a ruler. It is a familiar practical operation; but that is mensuration, not geometry. The geometer

proceeds as follows. Taking a circle as the easiest curve for simple illustration, we can suppose that inside the circle we inscribe a square ABCD and outside it we circumscribe a square EFGH as in the figure below.



The length of the circumference obviously lies between the values of the perimeters of the two squares. Now increase the number of sides of the inscribed figure so as to obtain an inscribed octagon AJBKCLDM and a circumscribed octagon PQRSTUVW. The circumference lies between the perimeters of the two octagons, and the limits are nearer to one another. We can conceive of this process being carried on until the inscribed and circumscribed regular polygons have each an enormous number of sides, each side being extremely short. Always the circumference lies between the two perimeters, and as the difference between these two perimeters is clearly diminishing to an infinitesimal amount, we regard the length of the circumference as the common *limit* to which each perimeter approaches as near as we please as we increase the number of sides indefinitely. Of course, it must be realised that the measurement of the sides of such a polygon by a *graduated ruler* is not implied nor required. (That would just be as much mensuration as using a thread on the

actual curve.) Euclid, in his fourth book, has proved certain propositions about such inscribed and circumscribed polygons which, when assisted by similar propositions discovered by later geometers, enable us to compare the length of a side of such a regular polygon with the length of the radius without resort to measurement of either. The circumference is, as the mathematician says, the " integral " of the infinitesimal lengths for the polygon with the unlimited number of sides, and the process he refers to as " integration." Similar processes can be applied to all other curves, and indeed to problems in a multitude of situations of quite a different character from this example, and the works describing methods and results are called text-books of the " Integral Calculus." With reference to the example shown, the reader should know that when he reads that the value of π (the famous Greek symbol which stands for the ratio of circumference to diameter) has been worked out to so many places of decimals, he must not imagine that it has been done by mensuration. A thread method as described above would barely give the first three places correctly. Even to obtain 3·14159 the integration process as described above or in some alternative way has to be employed, and it is only a matter of patience to carry the decimal much further.

Another illustration of the use of the notion of a limit is contained in the following statement. I write down the following fractions : $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$ and so on, each fraction having a denominator twice as large as its predecessor in the series ; now I add them travelling on indefinitely, that is I " sum the series "

$$\tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{8} + \tfrac{1}{16} + \tfrac{1}{32} + \ldots .$$

No matter how far I travel along I never reach a number as great as 1 for the result of the addition. True, I can approach as near to unity as I like by taking a sufficiently great number of " terms." As the mathematician says, the limit of the sum of the series is unity when it is " summed to infinity." Now it is perhaps natural to suppose that this series behaves like this, is " convergent " (to employ the usual phrase) simply because the successive terms are getting smaller and smaller. This is a complete misapprehension. If I write down the series

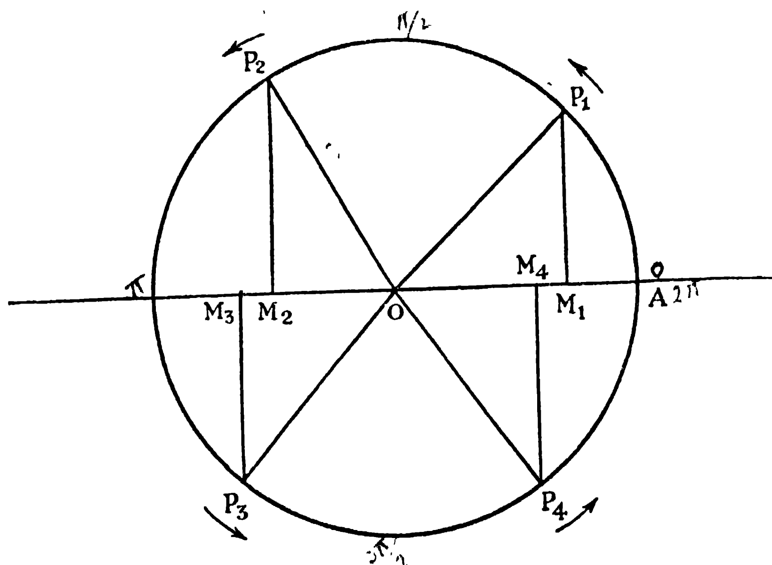
$$\tfrac{1}{2} + \tfrac{1}{3} + \tfrac{1}{4} + \tfrac{1}{5} + \tfrac{1}{6} + \ldots$$

it enjoys no such property of " convergency " ; it is " divergent " ; *i.e.*, there is no limit to the value of its sum if one embraces a large enough group of terms. Write down any number you please, no matter how large, and the sum can be made to surpass that number by adding up a sufficiently great number of terms. That may appear an astonishing statement to those uninitiated in these matters, but the proof of its truth is unassailable and may be found in any text-book of Algebra which has a chapter on " Convergency and Divergency of Series." Yet this series shows a progressive decrease in the values of the successive terms, just like the previous one. Obviously, then, the test for the convergency of a series is more delicate than that suggested above as plausible. Indeed the study of the tests for convergency and the limiting sums of series that are convergent form a branch of mathematical analysis which is not only invaluable in the study of the properties of functions (a purely mathematical

interest), but is also of immense practical value to those who wish to apply mathematical analysis to scientific and engineering problems. As is always the case, every new branch of mathematical investigation takes its rise in some practical need of man, then develops on its own account, as it were, by reason of his purely intellectual interests, and in so doing becomes a still more powerful aid to him in his control over the forces of the world and in his investigation into their nature and origin.

As one last illustration of this statement, let us recall the fact that many phenomena of nature show a recurrence of certain features as time goes on; they are periodic, as we say. Examples such as the recurrence of light and darkness, of the seasons; the rise and fall of the sea level in tidal seas and estuaries; the daily and seasonal fluctuations of temperature will leap to the mind of the reader. Many mechanical occurrences such as the swing of a clock pendulum, the oscillation up and down of a body at the end of a spring, the motion of water as ripples or waves pass across its surface exhibit the same features.

Consider for a moment the behaviour of a point which travels round the circumference of a circle at a uniform rate.



Starting at the point A, let it move round and let us denote by x the distance along the arc which it has actually travelled from the start to any position. We are for convenience considering the circle to have as its radius the unit length, so that when the line OP has turned round a right angle, $x = \pi/2$ (π is ratio of circumference to diameter), when OP has turned two right angles $x = \pi$, and so on; in fact x goes on steadily increasing; it is a variable which increases by the amount 2π in every complete journey of P round the circle. Now drop a perpendicular PM on the line OA. The lengths of PM and OM vary as x varies. They also are variables as well as x, but depending on the value of x, "dependent

variables " as they are called. They are in fact functions of x; the mathematicians call them " circular functions " of x. Actually they have long been in use as important measures of the angle POA, the " sine " and " cosine " of the angle as they are named. They originated in the needs of the surveyor and the navigator, and they are familiar to every navigating officer. But from the mathematician's point of view they are the " sine function of x," and the " cosine function of x," written $\sin x$ and $\cos x$ for convenience. Now the reader will observe at once that they are periodic functions of x, repeating their value when x increases by 2π. As x increases from 0 to $\pi/2$, the value of $\sin x$ is given by a length such as P_1M_1 at the appropriate position of P. It begins with the value zero when x is zero, and reaches the value unity when x is $\pi/2$. As x increases from $\pi/2$ to π, $\sin x$ (indicated by P_2M_2) decreases from 1 to 0. As x increases from π to $3\pi/2$, $\sin x$ changes in value from 0 to -1, having negative values for all intermediate values of x. (Observe that M_3P_3 is directed oppositely to M_2P_2 or M_1P_1.) As x increases from $3\pi/2$ to 2π, $\sin x$ alters from -1 to 0. Now as x increases from 2π to $5\pi/2$, $\sin x$ proceeds to pass through the same series of values as it did when x lay between 0 and $\pi/2$; and so on. Similar conclusions can obviously be drawn for $\cos x$. In fact if we give x any particular value, say 3,

$$\sin 3 = \sin (3 + 2\pi) = \sin (3 + 4\pi) = \sin (3 + 6\pi) \text{ etc.}$$

and

$$\cos 3 = \cos (3 + 2\pi) = \cos (3 + 4\pi) = \cos (3 + 6\pi) \text{ etc.,}$$

and any such statement is true for any other numerical value of x that may be chosen.

Actually then we have in these functions the most simple example of a wide range of functions of x, which enjoy this property of periodicity, or recurrence of value, as x steadily increases in value. To relate this fact to a statement concerning series made a few pages back, it is interesting to know that the mathematician can prove that the series

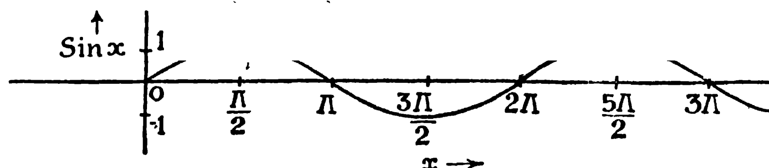
$$x - \frac{x^3}{3!} + \frac{x^5}{5!} \cdot \cdot \frac{x^7}{7!} + \frac{x^9}{9!} - \frac{x^{11}}{11!} + \ldots \text{ to infinity}$$

is convergent and its limit is $\sin x$. (Note that in putting the exclamation mark after the numbers in the denominator, we are indicating not the number but the " factorial of the number " as it is called. That is $2! = 1 \times 2$, $3! = 1 \times 2 \times 3$, $4! = 1 \times 2 \times 3 \times 4$, and so on.) The series

$$- \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \frac{x^8}{8!} \cdot \frac{x^{10}}{10!} + \ldots \text{ to infinity}$$

is also convergent and its limit is $\cos x$.

If we make a graph of the function $\sin x$ in the usual way, we reproduce the well-known " wave form."



In conclusion, these functions and others like them are the symbolic material which the mathematicians use when they wish to represent, in the only way possible, the quantitative aspects of the broad periodic phenomena of nature and of the experiments of the physicists made to discover the nature of those occurrences within the atom which give rise to the emission of light and which are believed to be periodic, or the nature of the propagation of light, or the nature of molecular quiverings in bodies which are believed to be the essence of the thermal properties of matter.

And so we end as we began. The material needs of man have, in the process of their satisfaction, raised for him purely intellectual problems. Driven by some inner urge to solve these, with no ulterior motive of any sort, he finds to his ever increasing astonishment that in their solution he discovers weapons which multiply his power over his environment a hundredfold. Intellectual pursuit as it is, Mathematics is of the very essence of the human spirit, and the literature in which it is enshrined ought to be one of man's proudest possessions.

BIOLOGY AND HUMAN PROGRESS

By

J. ARTHUR THOMSON

SYNOPSIS

What Biology means — Its central position among the sciences — Sub-divisions of Biology, *e.g.* Botany and Zoology — Sub-sciences of Biology, namely Morphology, Taxonomy, Physiology, Ecology, Embryology and Palæontology, Ontogeny and Phylogeny — An Outline Survey of the Great Events in Biology — The idea of Science as an instrument in man's service — Theoretical Discovery and Practical Invention — The Appeal to Biology as a science is very modern — Biology and Human Life : its Contributions : (i) Alleviation of the struggle for existence and increase of food and elementary amenities ; (ii) conquest of disease and increase of positive health ; (iii) elucidation and solution of great practical problems, *e.g.* of sex ; (iv) as a means of culture ; (v) as a foundation for eugenics ; (vi) as of ethical suggestion and guidance ; (vii) in forming part of the materials to be appreciated in a synoptic or philosophical view — Biology and Philosophy — The Wonder of Life, *e.g.* (1) the abundance of power, (2) the multitudinousness and diversity of organisms, 3) the intricacy of organic architecture, (4) the adaptiveness of living creatures, (5) positive and exuberant healthfulness, (6) the increasing dominance of mind, and (7) the fact of Evolution — Descriptive Naturalism — Vitalism — Psycho-Biology — Organic Evolution and the operative factors — As regards Variations — As regards Heredity — Struggle and Selection — Isolation — Evolution going on.

BIOLOGY AND HUMAN PROGRESS

The term Biology is used in three or four different ways. (1) It may mean the generalised science of the nature, continuance and evolution of organisms, and it is in this sense that it is for the most part used in this article, just as in Spencer's classic *Principles of Biology*. (2) But it is often used as a collective term for all the Life Sciences, which include Botany, Bacteriology, Zoology, Protozoology and so forth, and also for the biological sub-sciences of Anatomy, Physiology, Embryology, Genetics and the like. Thus in one great University all the sciences or sub-sciences that we have mentioned are under one roof—the Biological Institute or the Hall of the Life Sciences.

(3) An English book entitled *The Biology of Spiders* or *The Biology of Flowering Plants* would contain a discussion of the group in question in order to illustrate in this particular field the general principles of Biology. (4) Unfortunately, however, a German book entitled *Die Biologie der Spinnen* (The Biology of Spiders) would be entirely devoted to Ecology, that is to say, the study of inter-relations and habits, adaptations to seasons and surroundings, the intimate life of the pair, the family and so on—in short, the old-fashioned Natural History. This fourth usage is unfortunate and should not be allowed to impose itself. The first two usages are necessary and convenient.

Biology is central among the concrete sciences, with Chemistry and Physics (hardly separable now) beneath it and fundamental to it; with Psychology and Sociology above it and fundamentally based on it. Thus we have the convenient Spencerian scheme :—

SOCIOLOGY	Societies and their Life
PSYCHOLOGY	The Inner or Subjective Life
BIOLOGY	Living Organisms
PHYSICS	Energy and its Transformations
CHEMISTRY	Matter and its Changes

Yet in some ways it seems clearer to recognise only three great Orders of Facts :—

1. The *Cosmosphere* of non-living things and forces, from dewdrops to stars, from electricity to gravitation.
2. The *Biosphere* of living organisms, both plants and animals ; and
3. The *Sociosphere*, consisting of human societary forms acting as units, and with a dominant social heritage, enregistered in institutions, literature, art, traditions, and all sorts of permanent products.

This threefold classification has certain advantages; *e.g.*, that Chemistry and Physics are no longer readily separable, for Matter has been analysed into Energy; and similarly that Biology and Psychology (regarded as the science of behaviour) are inextricably intertwined. Thus we may think of three circles one within the other:—

(1) The domain of non-living things and forces (Cosmosphere).
(2) The realm of organisms (Biosphere); and innermost
(3) The kingdom of man (Sociosphere).

The inclusion of one circle within the other will suggest the useful idea that there is a chemistry and physics of the living body, just as there is a biology and psychology of societary changes. When beavers make a canal, the biosphere is taking part of the cosmosphere into its realm; when man irrigates a country like Egypt or India, he is doing the same. When microbes cause a plague, the biosphere is overwhelming part of the sociosphere; yet when man domesticates and cultivates he is taking part of the biosphere into his kingdom.

SUB-DIVISIONS OF BIOLOGY

It is a matter of convenience how many Biological Sciences we recognise. Everyone admits Botany for plants and Zoology for animals, but as specialisation of study increases, it becomes plain that Bacteria are very different from all other living creatures, and thus Bacteriology arises; whereupon the specialists on unicellular animals insist also on Protozoology; and Protistology is further suggested as a title for the study of those minute organisms which are not very definitely plants, or animals, or bacteria. Then each class asserts its claims, and Entomology, Ichthyology, Ornithology and so forth get a footing on the list. And so for the science of special groups of plants, such as mycology for the science of fungi. But here there is no confusion, such as begins to show itself when highly specialised lines of inquiry demand rank as particular sciences; *e.g.*, parasitology for the study of parasitism, conchology for the study of shells, and oology for the study of eggs!

The following scheme should make the matter clear:—

- BIOLOGICAL SCIENCES
  - BOTANY
    - BACTERIOLOGY
    - MYCOLOGY
    - and other sub-sciences
  - ZOOLOGY
    - PROTOZOOLOGY
    - GENERAL ZOOLOGY
      - ENTOMOLOGY
      - ORNITHOLOGY, etc., etc.
    - ZOOLOGICAL ANTHROPOLOGY

There is, of course, room for reasonable difference of opinion in regard to details. Thus there is something to be said for removing Bacteriology from within the rubric of Botany. Or again, while much of anthropology is definitely sociological, the study of man's structure, functions, development and pedigree may be conveniently, and without prejudice, retained

under Zoology. It comes to this: that under the collective title Biology (=Life Sciences) a variable number of sciences may be included.

In a different group, however, are the so-called Applied Sciences, such as Agriculture, Veterinary Science, Fisheries, Genetics, Hygiene, and much of Medicine, where we have to do with the focussing of a pure science, or of several pure sciences (Biology included), on a particular group of practical problems. These applications of science have meant much to human progress and also to the advancement of pure science itself. Practical invention often springs from theoretical discovery, and reacts on its origin.

SUB-SCIENCES OF BIOLOGY

There are four great questions that Biology is always asking, and the answers to *each* of these four give rise to two sub-sciences, according as the scrutiny is confined to the individual organism or to the race. The first question is: *What is this?* as a whole and in its parts, to the naked eye or under the microscope. This is the study of structure, the statical aspects of the organism—in a word, MORPHOLOGY. It includes anatomy by means of forceps and scalpel, and histology by means of microscopic sections and other technique. If we begin at what may be called the biological renaissance, with the anatomist Vesalius (1514–1564), "the emancipator of biology from the tradition of the ancients," and with Harvey (1578–1657), the demonstrator of the circulation of the blood, we may sum up the subsequent analysis of structure as a more and more penetrating analysis of the organism into its organs, its tissues, its cells, and its protoplasm. We follow our teacher and colleague Patrick Geddes in this scheme, which suggests both the historical and the logical sequence:—

	THE INTACT ORGANISM	*e.g.*, Linnæus
	ORGANS	*e.g.*, Cuvier
MORPHOLOGY, the Science of Structure	TISSUES	*e.g.*, Bichat
	CELLS	*e.g.*, Schwann & Schleiden
	PROTOPLASM	*e.g.*, Max Schultze

But when we pass from the individual organism to the group or race, we begin the science of orderly arrangement or classification—TAXONOMY, which is based on the study of structure, but rises beyond it. As everyone knows, the tigers form the *species Felis tigris* in the *genus* Felis, which also includes lions and leopards, cats and jaguars. But the genus Felis is not distantly related to the genus of cheetahs (Cynælurus) and together they

form the *family* Felidæ. But along with the cats must be ranked the wolves and foxes, the bears and otters, forming the *order* Carnivora. This again is within the *class* of Mammalia in the Group or *Phylum* of Backboned Animals or Vertebrata. So the scheme of classification stands :—

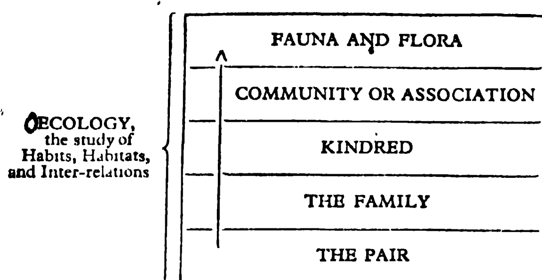
TAXONOMY, the study of Classification	PHYLUM OR GROUP	*e.g.*, Vertebrata
	CLASS	*e.g.*, Mammalia
	ORDER	*e.g.*, Carnivora
	GENUS	*e.g.*, Felis
	SPECIES	*e.g.*, Felis tigris

But the second great biological question is : *How does this organism work ?* How does it continue in being, what are its activities, its dynamical aspects ; and the answer to this question is the sub-science of PHYSIOLOGY. And just as with Morphology, so with Physiology, the history has been a gradually more penetrating analysis, from the intact organism, with its creeping, running, swimming, flying and so forth, to the functions of the various organs, such as the beating heart and the filtering kidneys. Thence to the properties of tissues, *e.g.*, the irritability of nerves and the contractility of muscles. But this leads to the everyday life of the component cells that build up tissues in most living beings. Whence there is but another step to the chemical and physical changes and their regulation within the protoplasm which Huxley called " the physical basis of life." So again the same logical and factual scheme appears :—

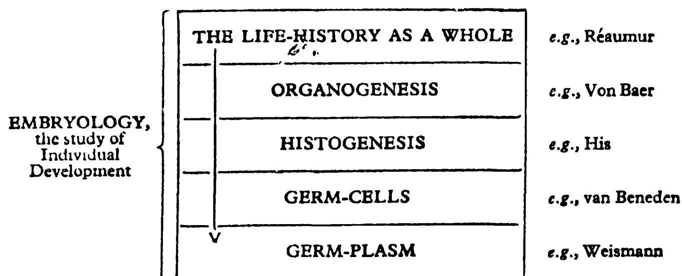
PHYSIOLOGY, the study of Function	THE ORGANISM AS A WHOLE	*e.g.*, Old Naturalists
	FUNCTIONS OF ORGANS	*e.g.*, Harvey
	PROPERTIES OF TISSUES	*e.g.*, Bichat
	LIFE OF CELLS	*e.g.*, Virchow
	VITAL CHANGES IN PROTOPLASM	*e.g.*, Claude Bernard

But there is a " higher physiology," which emerges when we envisage organisms, especially animals, in the plural, as members of a group or race, an association or community. This is the old-fashioned Natural History, which is becoming the precise sub-science of ECOLOGY, the study of habits and habitats, of inter-relations and linkages, at the various levels

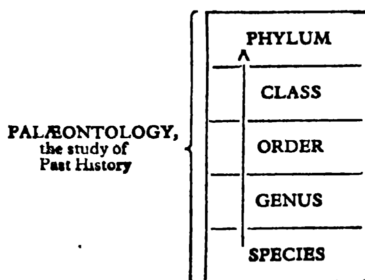
of pair, family, kindred, community, fauna—all considered from the physiological point of view. Thus the scheme stands :—



The third biological question is : *Whence?* In what form did this organism begin, and through what stages did it come to be as it is? When this question is answered for the individual, the result is the sub-science of EMBRYOLOGY—the science of development or individual Becoming. And here again there must be a sequence of steps—from the more superficial to the deeper aspects :—



But the same question *Whence?* may be asked for the group or race to which the organism belongs; and the answer, dug out of the fossil-bearing rocks, is the sub-science of PALÆONTOLOGY, the study of pedigrees or racial Becoming. So the scheme reappears :—



The fourth biological question is the most difficult : *How have the forms and functions of life come to be as they are?* The question "Whence?" is answered for the individual by Embryology and for the race by Palæontology—not that any answer is within sight of completeness, but the new question is into the "How?" of the "Thence," a question into causes, into the factors operative in the development of the individual (Ontogeny) and in the evolution of the race (Phylogeny). This is what Huxley called ÆTIOLOGY, with its two sub-sciences of Evolution-Theory and Physiological Embryology or Development-Theory.

This mapping-out of Biology may seem to the newcomer very academic, but it is essential to an understanding of the aims and methods of the science, and it gives a background against which particular advances can be seen in perspective. If we lift up the rectangles and piece them together we get Geddes's map of Biology (slightly modified) in which we see more and more the longer we study it.

BIOLOGY

GROUP	PALÆON-TOLOGY	TAXON-OMY	ECOLOGY	EVOLU-TION THEORY	Phylogeny of Race
INDI-VIDUAL	EMBRYO-LOGY	MORPHO-LOGY	PHYSIO-LOGY	DEVELOP-MENT THEORY	Ontogeny of Individual
	STATIC		DYNAMIC		

GREAT EVENTS IN BIOLOGY

(*A slow reading of this historical section will reward the student, but it may be postponed to the end of the Article.*)

The foundation-stones of Biology were laid by Aristotle (384–322 B.C.), a great initiator, anatomist and embryologist, as well as naturalist-observer. But centuries passed before he found an outstanding successor —namely, Galen (A.D. 131–201)—who returned to actual dissection and initiated experimental physiology. Then came the ages of preoccupation and tradition, and (apart from a few irrepressible observers) it was not till the sixteenth century that the fetters were broken. The Belgian anatomist, Vesalius (1514–1564), insisted effectively on an independent scrutiny of facts, and an even greater initiator of later date was William Harvey (1578–1657), who demonstrated what some precursors had hinted at—the circulation of the blood. This was a great discovery in itself, but it was

also epoch-making as the first proof that some activities of the living body may be in some measure described in terms of mechanics. For Harvey showed how it was that the blood was forced to go round the body.[1] Harvey was still a believer in the old theory of spontaneous generation (that living creatures may arise from non-living matter), but he had a remarkable prevision of the fact that "all animals are in some sort produced from eggs," and of the fundamental idea that in the apparently simple germ from which an animal, such as a chick, is developed, "no part of the future organism exists *de facto*, but all parts inhere *in potentia*." Thus he contradicted the long-lived notion that a preformed miniature of the future animal lay within the germ-cell, only requiring to be unfolded.

Among the early foundation-layers we are inclined to include the Italian, Redi (1626–1698), for the clear-cut experiments by which he disproved alleged cases of spontaneous generation—a tenacious heresy to which the convincing experiments of Pasteur and Tyndall hardly sufficed to give a death-blow. Also fundamental was the work of the early microscopists—some would trace the compound microscope back to Galileo about 1610—for besides disclosing a new world of minutiose life and a new intricacy everywhere, they showed how the invisible illumined what had previously been obscure. Thus, while Harvey proved the circulation of the blood, he did not know of the invisibly delicate capillaries which connect the ends of the arteries with the beginnings of the veins, and make the whole *a closed system* of vessels. These capillaries were demonstrated in the frog's lung by Malpighi (1628–1694), born in the year of the publication of Harvey's *De Motu Cordis et Sanguinis*. Similarly, the everyday life of insects was not intelligible until some of the early microscopists, like Swammerdam (1637–1680), showed how the respiratory tubes or tracheæ divide into microscopically minute branches which carry air to every recess of the intricate body. Thus the invisible makes the visible intelligible. Great honour is also due to Leeuwenhoek (1632–1723), an investigator of splendid achievement, who discovered not merely Infusorians but Bacteria and spermatozoa.

At this stage we must recall, from the preceding section, the useful general idea that the history of Biology shows a more and more penetrating analysis, from organisms to organs, from organs to tissues, from tissues to cells, from cells to protoplasm. With this as general clue, we shall now very briefly recount some of the events that seem to us most momentous, always admitting that in this matter there is room for considerable difference of opinion.

Linnæus (1707–1778), often called "the Father of Botany," laid the foundations of Classification (Taxonomy) and struck a new note in including Plants and Animals under the common title "Organisata." What is now a commonplace was a great discovery in its day, that Plants and Animals are equally alive, though on very different lines.

Cuvier (1769–1832) laid the foundations of Comparative Anatomy, and expounded the idea of the correlation of organs in the body, showing, for instance, that all mammals with hollow horns have cloven hoofs. He also began to do justice to fossils as relics of extinct types.

Goethe, an early evolutionist, and thus siding against the conservative

Cuvier and with Geoffroy Saint-Hilaire and Lamarck, invented the term "morphology," and illustrated with vivid clearness the concept of homology or deep-seated resemblance in structure and development. He was one of the first to discern the real nature of the flower, which he recognised as four whorls of much transformed leaves. He had a vivid interpretative insight into the unity of plan underlying great series of organic structures.

Lavoisier (1743–1794), the main founder of modern chemistry, is ever memorable in the history of Biology for his recognition of the oxidation-process that all living involves. He saw that the burning candle and the panting mouse were both illustrating combustion.

After Stephen Hales (1677–1761) initiated vegetable physiology and Priestley (1733–1804) discovered, or re-discovered, oxygen, and after hardly less important steps taken by Ingenhousz (1730–1799) and De Saussure (1767–1845), there began to be some understanding, still incomplete, of the process of photosynthesis—the most important vital process in the world—by which green plants use part of the energy of sunshine to build up nutritive carbon-compounds from carbon dioxide and water.

Liebig (1803–1873) was pre-eminent in demonstrating the circulation of matter, a fact of the deepest importance in Biology. He showed in a luminous way how the elements, *e.g.* carbon, nitrogen, sulphur, iron, pass from one chemical linkage to another in endless cycles.

In 1838–1839 Schwann and Schleiden formulated the Cell-Theory, Goodsir and Virchow being contemporary discoverers, and Lamarck a notable anticipator. The Cell-Theory includes three propositions: (1) all organisms have a cellular structure, being either single-celled (the Protozoa or simplest animals and the Protophytes or simplest plants) or multi-cellular (the Metazoa and the Metaphytes); (2) every multicellular organism, reproduced in the ordinary way, begins as a fertilised egg-cell, which develops into an embryo and young creature by continued division and differentiation of cells; (3) the life of the multi-cellular organism is the regulated and unified sum of the lives of the component cells. This Cell-Doctrine, as it should be called, is one of the foundation-stones of Biology.

The Russo-German investigator, Karl Ernst von Baer (1792–1876), was the founder of Comparative Embryology, and one of the first to discern that individual development (Ontogeny) is in some measure a recapitulation of racial evolution (Phylogeny). Development, he said, proceeds from the generalised to the more specialised; the developing heart or brain of a mammal goes through stages which are permanent in less highly evolved backboned animals.

A very important step associated with the names of Dujardin, Von Mohl, Max Schultze and Cohn, about the middle of the nineteenth century, was the extension of scrutiny beyond the cell to its contents of living matter or protoplasm. It is difficult for us to realise that it was only about that time that biologists discerned that all organisms have protoplasm in common, specific though it is for each particular type. All living creatures are built up of similar material, and yet it has an individuality for each definite kind.

Another milestone was Wöhler's building up or chemical synthesis of

urea in 1828, urea being the very characteristic waste-product in the urine of mammals. This was the breaking down of the blockading wall between what goes on in non-living Nature and what goes on in the living body. It was also the initial step in that remarkable series of syntheses by which the chemist—almost creative—has artifically built up not only sugars and alcohols, but amino-acids which have been called the building-stones of life, besides such precious substances as thyroxin (the hormone of the thyroid gland) and adrenalin (the hormone of the supra-renal bodies). Hormones are chemical messengers of great potency which are produced in the *ductless* glands, such as the thyroid and the supra-renal, and are distributed by the blood throughout the body. They affect the activity of certain parts in a very remarkable way, sometimes accelerating, sometimes putting on a brake. They are indispensable to health, for they regulate the activities of the body.

Much physiological progress was due to Claude Bernard (1813–1878), who established experimental physiology on a firm foundation; discovered that one of the great functions of the liver is to make glycogen or animal starch, an important nutritive reserve; and distinguished the up-building (anabolism) and the down-breaking (katabolism) which alternate with one another in the chemical routine (or metabolism) of the body. Of fundamental importance was his famous book, *Phénomènes de la Vie communs aux Animaux et aux Végétaux* (1878), in which he showed the deep resemblances between Plants and Animals in their main vital processes, except as regards the photosynthesis or up-building of carbon-compounds, which goes on in all green leaves. Later on this rapprochement of Plants and Animals was extended to a recognition of the deep similarities, in spite of superficial differences, in the reproductive processes in the two sub-kingdoms. Very noteworthy was the clearing up (by Steenstrup and others) of the alternation of generations in various classes of animals, such as zoophytes, and the masterly work of Hofmeister, who traced the same alternation of generations from Liverworts and Mosses to Ferns and Lycopods, and thence to Flowering Plants where it is so well concealed. This is a long story, but it may be enough here to notice that an ordinary asexual Fern-plant produces spores which develop into minute sexual prothalli. From fertilised egg-cells produced by the prothallus, and fertilised by sperm-cells, there develop the familiar spore-producing fern-plants.

Much progress was due to August Weismann (1834–1914) who thought out the first coherent theory of heredity. By his demonstration and understanding of "the continuity of the germ-plasm," he explained, for the first time clearly, how like tends to beget like; he focussed the idea that new departures or variations are due to changes in the germ-cells; he anticipated the modern theory of hereditary "factors" or "determinants," now called "genes"; and much has followed from his damaging, if not destructive, criticism of the evidence adduced in support of the Lamarckian theory of the transmissibility of individually acquired somatic modifications. The continuity of the germ-plasm means that when a fertilised egg is developing into an embryo, part of the germinal material is not used in body-making, but remains apart to form the beginning of the reproductive organs of the offspring.

To Pasteur may be referred the modern recognition of the manifold rôle of Bacteria and of the fundamental part that enzymes or ferments play in vital processes. For there can be no approach to an understanding of the activities of living creatures unless we recognise the marvellous power that ferments have of accelerating chemical changes. To Bayliss and Starling, about 1904, is due the demonstration of the rôle of "hormones," to which we referred above. They are the almost magically potent secretions of the ductless glands, and they serve as regulative agents in the healthy functioning of the body. Diseases like diabetes and cretinism are due to disturbances in the working of the hormone-making glands.

The great pre-Darwinian evolutionists were Erasmus Darwin, Buffon and Lamarck—the last the greatest, especially perhaps in his recognition of Psycho-biosis or the mental aspect of life. For Lamarck had a vivid appreciation of the share that an insurgent, wilful, struggling organism, full of need or "besoin," may have in its own evolution. To Charles Darwin and Alfred Russel Wallace the debt of Biology is great and manifold; but their theory of Natural Selection stands out prominently. That is to say, they discerned the scope and subtlety of the unconscious sifting that is involved in the struggle for existence.

Epoch-making beyond doubt, though unrecognised in his lifetime, was Mendel, who discovered the mode of inheritance which bears his name. Along with Weismann—who was chiefly concerned with germ-cells—and Francis Galton—who applied statistical methods—Mendel helped to lay the foundation-stones of the sub-science of Genetics, which he based on experiment.

Very influential has been the discovery of the dual nature of lichens by De Bary (1866) and Schwendener (1868), who showed that these plants express an intimate partnership of a particular Fungus and a particular Alga. This was an important discovery in itself, but it also led on to the recognition of many other forms of symbiosis, as the mutually beneficial internal partnership is called, and of other linkages as well, such as the interesting external partnership known as commensalism, which is well illustrated by the "mutualism" between certain hermit-crabs and certain sea-anemones. The idea of inter-relations or linkages in an ever-complexifying web of life was in the mind of old-fashioned naturalists like Gilbert White, and it was central to Charles Darwin's thinking.

Among other foundation-stones we may mention the intimate analysis of ordinary (mitotic) cell-division, remarkable for the meticulous accuracy with which half of each structure in the parent-cell passes into each daughter-cell; the discovery of the peculiar mode of cell-division known as meiotic, which occurs at the maturation of egg-cells and sperm-cells and is remarkable because the *number* of the nuclear rods or chromosomes is halved for each daughter-cell; the recognition of these chromosomes as the specialised bearers of the initiatives or "genes" of the hereditary characters; and the deepening of knowledge in regard to what happens when a sperm-cell fertilises an egg-cell.

Thomas Graham's study (1861) of osmosis and his disclosure of the properties of matter in a colloidal state has proved of fundamental importance in modern physiology; and we must single out Hardy's proof, about 1899, that active protoplasm has no microscopically visible framework,

but is a fluid system, with not less than 70 per cent. of water, in which are suspended innumerable ultra-microscopic mobile particles and unmixing droplets, presenting a large sum-total of surface on which chemical and physical changes may take place.

Mention should also be made of the introduction of a new organon in biological investigation—namely, statistical methods or biometrics. This has yielded valuable results in the skilful hands of Galton and Pearson, Weldon and Pearl, and has a promiseful future before it.

Also fundamental, we may almost say essential, is the critical study, by investigators like Lloyd Morgan, of Animal Behaviour at its many levels, and the recognition of the rôle of " Mind " as a *vera causa* in Organic Evolution and in the unending Drama of Life from day to day.

SCIENCE IN MAN'S SERVICE

Since Man came to his own as a wide-awake intelligence, he has been familiar with the idea of utilising expert knowledge as a guide in facing practical difficulties. Even in prehistoric days there must have been expert lore to which appeal was made. Men took counsel with the elders of the tribe, the magicians, the priests, and, later on, with the wise men—who correspond to our scientists. In everyday routine it was enough to follow tradition and the dictates of common sense; but in face of crises there was an appeal to experts or supposed experts. This was the beginning of what is increasingly characteristic of modern times—the habit of using science as a guide in practical affairs. As a practical policy this habit is in greater part modern, though the germ of it is as old as mankind. Thus it seemed a new idea that Herbert Spencer promulgated in his epigram : Science is for Life, not Life for Science.

Man, like the rest of creation, often illustrates " the principle of least action," as the Earth in its orbit; that is to say, he prefers to avoid taking trouble or thought, he trusts to tradition and to common sense as far as they will take him. For science is difficult to understand, and consulting the wise man or scientific expert usually involves a fee. Thus men built beautiful boats and bridges by rule of thumb, and the old-fashioned farmers and breeders succeeded wonderfully well without any agricultural chemistry or Mendelian genetics. " Wonderfully well," we say, yet often very wastefully, often very slowly, and sometimes not at all—being hindered or baulked by lack of understanding. Yet for many centuries tradition and common sense worked not so badly, especially in regard to the easier practical problems.

Gradually, however, with increase of population and the quickening of the pace of life, it became necessary to get more coal and iron out of the ground, more wheat from the fields, more fish from the sea, besides quickening transport with locomotives and steamships, and shortening distances with great bridges, tunnels and the like. We need not elaborate, for it is well known that in one field after another novel difficulties had to be faced, and an appeal to science became more and more imperative. Meanwhile, after the Renaissance—say from the classic works of Copernicus and Vesalius in 1543—the sciences themselves had been growing, as the outcome of man's irresistible inquisitiveness and desire to discover

causes; and although their main *motif* was always towards fuller understanding, they became increasingly able and willing to assist, as Bacon put it, in the relief of man's estate. Thus and thus there arose what are somewhat unhappily called the Applied Sciences, such as Agriculture, Engineering, Metallurgy, Navigation and so on through a long and lengthening list. They consist of applications of Pure Science to particular practical problems or crafts, and it is only in so far as they conform to this description that they can be called scientific. For they often include masses of information which do not rise high above the old empirical lore in which all science began. Naturally enough, the sciences that were first appealed to were those that had made most progress—the exact sciences of Physics, Chemistry, Astronomy, Mechanics and the like. The appeal to Biology as a science is quite modern, practically post-Darwinian.

To this last statement exception may be taken on the ground that Medicine has always been appealed to, and Medicine goes back to Hippocrates (born about 470 B.C.), who was of high rank as a scientific thinker. But the apparent exception is not a very real one, for the old-established custom of sending for the physician when life was menaced was for many centuries rather an appeal to an art or to an honourable craft than to science as such. No doubt the end of the Dark Ages saw, in the work of pioneers like Vesalius (1514–1564), the beginning of the laying or relaying of the scientific foundations of medicine, but the idea of medicine as a biological science is in the main post-Darwinian. It may indeed be dated from Pasteur with his germ-theory of disease, or from Virchow with his "Cellular Pathology." We do not wish to over-labour the distinction, but the metamorphosis of the Art of Medicine, from a craft to a science, is distinctively modern, and the long-standing habit of sending for the physician is not much of an exception to our conclusion that man's appeal to Biology is a quite recent development.

Discovery and Invention

It has been said that apart from prophets, priests and kings no single man ever changed the face of civilisation so much as Newton; and in any case it is agreed by all that he was one of the great initiators, giving man keys which opened practical as well as theoretical doors. His work is a good illustration of the important fact which the history of science proves, that most of the vitally important practical inventions are based on recondite researches in Pure Science. If we think of such devices as telegraphy, telephoning, broadcasting, the use of rays in medicine and surgery, the serum treatment of disease, we find that they are based on very theoretical researches and discoveries. It we use Bacon's memorable phrases for the twofold function of science as light-bringing (luciferous) and fruit-bearing (fructiferous), we may safely say that the first conditions the second, theoretical discovery preceding practical invention. At the same time we are bound to recognise that some urgent practical need or some wave of emotion has often given point and purpose to scientific research. Thus although Lister was from his inborn scientific curiosity interested in physiology and in microbes, it was, he tells us, the tragedy of the high mortality in the hospital wards that urged him towards his

antiseptic methods. Similarly with Pasteur, whose early researches on tartrates were as theoretical as his later ones were practical.

The historical point is that the successes of science in solving practical problems gave the public a respect for science as such; and this accounts for the early recognition of the value of chemistry and physics and mechanics, and the tardy recognition of biology and psychology. Is there a demand for a new drug or dye, a new fuel or explosive, the citizen has now learned to look to chemistry; but the time has hardly come when the problems of population or of human inheritance immediately suggest an appeal to biology. Is there a question of a difficult bridge to be built or a more reliable airship, it would be regarded as extreme folly to experiment without the scientific expert; but the citizen has hardly realised that it is almost as absurd to make educational experiments apart from the advice of the psychologist, or environmental and occupational experiments without consulting the biologist. It comes as a surprise as yet to hear a prophetic appreciation of what Biology may mean for human life, as when Sir Walter Morley Fletcher recently startled the public by saying in a National Broadcast, that " we can find safety and progress only in proportion as we bring into our methods of statecraft the guidance of biological truth."

The Appeal to Biology very Modern

To understand the position to-day we must recognise, as we have said, the greater prestige of chemical and physical science as compared with Biology. This is the natural outcome of: (1) The more advanced state of the exact sciences, and (2) the many impressive triumphs which have rewarded the application of these sciences to the service of man. But since Darwin's day the science of Biology has become more mature and more exact, and it also has some triumphs of practical application; *e.g.*, in connexion with Mendelian breeding, the life-history of formidable parasites, the rôle of vitamins in diet and of hormones in health. Thus the eyes of many citizens of the world are now beginning to think of Biology as a possible light to their feet and lamp to their path. This appeal will become more insistent in proportion as ordinary men and women turn from traditional and vaguely instinctive promptings to face the facts and to demand scientific guidance—biological as well as physical.

BIOLOGY AND HUMAN LIFE

Assuming, alas! with considerable warrant, a critic who smiles at the idea of Biology having anything to do with civilisation, let us state the case for our science. How are we to classify the services that Biology renders to Man? First, there are the direct contributions which alleviate the struggle for existence by increasing the food supply and improving the more elementary amenities of life. Second, there is the assistance that Biology offers: (*a*) in the conquest of disease; and (*b*) in the quest for positive health.

Third, there is the biological counsel which is already available in regard to certain perennial problems of human life, such as those centred in

sex. Fourth, there is the genetic basis of eugenics. Fifth, there is the cultural value of biological study. Sixth, there is the ethical value of Biology as a guide in conduct. And seventh, there are the contributions that Biology offers to our synoptic (philosophical and religious) outlook on the world as a whole.

I. Biology and the Struggle for Existence

Though man does not live by bread alone, food is his first need ; and Biology can certainly help him to make two blades of grass grow where only one grew before. And all flesh, however carnivorous, is in the long run grass. Biologists have discovered the secret of the success of leguminous plants, that they have partner-bacteria in their root-tubercles which are somehow able to capture the free nitrogen in the soil-air or soil-water. These friendly symbiotic microbes add to the plant's nutritive reserves of nitrogenous carbon-compounds, and if the crop is systematically dug in or ploughed in, then poor soil will become good soil, and there will be more food for man and beast. In several ways Biology is instructing the agriculturist how to reclaim waste places, and if success rewards the promising experiments now begun on transforming peat-bogs into crop-growing fields it will be a great day for many a crofter. If the population of the globe goes on increasing at its present rate, with an absolute addition of 12-14 millions every year, a terrible struggle for food is in prospect. If Biology can increase the food supply—a power which no one doubts—there is a greater chance of avoiding a *débâcle* before the birth-rate is reduced to meet the conditions of existence. Thus at the very outset we see how Biology may contribute to the welfare of civilisation.

What an advance there is from the wild wheat still growing on Mount Hermon to a first-class modern wheat like Marquis, an advance not only in number of seeds, but in their nutritive value. Especially of recent years there has been a remarkable patience of sifting on the part of experimental biologists devoted to wheat and, if we are on the outlook for significance to mankind, we must remember that Marquis Wheat was certainly one of the factors that won the Great War.

The methods of the Mendelians make it possible to graft on to a prolific wheat various other good qualities, such as early ripening or a texture that grinds well and yields attractive flour. Some ten years ago Professor Punnett, one of the leading geneticists of Great Britain, said in a lecture :

> " Take wheat alone. Biffen's work has already added hundreds of thousands of pounds yearly to the wealth of this country. Howard in India has produced a new wheat which is now spreading over the Central Provinces and is expected shortly to increase the annual value of the crop in that area alone by £7,000,000. The experiment station in Ohio is supplying the farmers of that State with a wheat that produces on an average an increase of two bushels to the acre on those previously grown. With two million acres under this cereal the gain is obviously considerable."

Since this was said the improvement of wheats has continued, and the magnitude of the biological advance is not fundamentally affected by the complex social and economic conditions that have robbed wheat-growers in Britain, for instance, of much of their reward, and have made the loaf dearer not cheaper. We are not here called on to enter these deep waters.

What botanical biology has done for wheat—one instance out of many—zoological biology has done for many animals. Breeds of poultry have been established in which the individual hen may lay two hundred or more eggs in the year. In a limited freshwater area it is possible to multiply the trout, even by the rough-and-ready method of pitching cart-loads of bracken into the water. As we have said elsewhere : " Bacteria working on the bracken thrive and multiply, they afford food for infusorians, and they also liberate the stimulants of vegetative growth. The replenished hosts of infusorians and Algæ are devoured by minute Crustaceans, which afford food for freshwater fishes. Here we have a hint of a possible correlation between bracken and breakfast. And while the sceptic and patriot may refuse to cast his bread on the waters, who would not cast bracken which is conquering all too easily in the struggle for existence with much better plants ?" There would be more chance of checking the deplorable ruin of pasture by bracken—a ruin for which a cure is on the horizon even as we write—if some use could be found for the fern, and what could be better than turning it into trout and thus, eventually, into man ! Whether we think of wheat or of trout we see a scientific echo of the miracle of multiplying loaves and fishes ; and there is no irreverence in recognising this.

Our thesis is that Biological Science helps to spread man's table ; and there are many ways of doing this besides directly increasing the supply of edible plants and animals. Under expert control there may be great increase of a country's wealth by the naturalisation of useful plants, like fruit-trees at the Cape, and useful animals, like sheep in New Zealand. Great things have been done in the way of saving crops and herds from formidable parasites and from less insidious enemies. An almost ideal utilisation of animals is illustrated by bee-keeping. The honeymakers have not been much deteriorated by their masters, however they may have suffered from their own servile state. They do not require much artificial nurture, and would probably be better with less. They produce a very delightful food at a minimum cost to man. There is no reason save slackness why a country like Britain should not flow with honey. And if the critic naturally reminds us of the " Isle of Wight " disease which has ruined so many apiaries from Ventnor to Cape Wrath, the reply is that the parasitic mite associated with this malady has been discovered, and that ways are being devised for circumventing its ravages. In a score of similar cases the dramatic sequence of events has been the same : a disease crops up with disastrous results ; the cause of the disease is discovered by the biologist ; and then there follows either cure or prevention. Very dramatic and not less effective is the prevention of some of the scale-insect diseases of imported fruit-trees, notably the oranges and lemons of California, by also importing the natural insect-enemies of the scale. This also is spreading man's table.

We do not wish to dwell longer on the contributions made by Biology

to the bread-and-butter problem, though these are far-reaching and will increase in importance if the world's population goes on growing at its present rapid rate. Before the appearance of notices saying " Standing Room Only " there is likely to be a struggle for subsistence too terrible to think of, yet it is *possible* that some momentous bio-chemical discovery will alter the whole aspect of the nutritive problem. This might come about, for instance, if there is confirmation and extension of Professor Baly's synthesis of sugar and other carbon-compounds by the action of light on carbon dioxide and water. This is not our present business, yet we must keep in mind the achievements of the almost creative chemists, even to the artificial synthesis of the amino-acids which have been called the building-stones of living matter. Nor should we forget how waterfalls are now used to produce great discharges of electricity which capture some of the free nitrogen of the air, binding it into ammonium nitrite or the like—the basis of " fertilisers " which increase the yield of wheat. So, in a way, science makes bread out of the thin air. This, then, is our first point, that Biology spreads man's table.

II. Biology in Relation to Health and Disease

It was a momentous event in civilisation when Pasteur demonstrated the microbic nature of many diseases. We can hardly realise the change in the entire outlook, not only of medical experts, but of ordinary citizens when it was clearly seen that disease is no mysterious power suddenly emerging out of darkness and clutching man by the throat, but is in many cases due to the invasion of the body by a microbe—a microscopic living creature that can be contended with and often conquered. Discovery of causes was followed by discovery of cures, and then there arose a system of Preventive Medicine which vindicated man's natural love of light, fresh air and cleanliness, and showed in prosaic detail how infection might be in many cases avoided. There followed a recognition that some very important diseases, such as malaria and sleeping sickness, were caused not by Bacteria, which are generally regarded as of the nature of single-celled *plants*, but by Protozoa, that is to say, by intruding microscopic *animals* which destroy or poison the living cells of the body. And as an invaluable contribution of Natural History to Medicine there has arisen a fascinating department of ecology which deals with the carriers of the disease-microbes and of the larger parasites. Thus, as everyone knows, various kinds of mosquitoes carry the various malaria-organisms, and the tsetse flies are the disseminators of sleeping sickness. With a deepening knowledge of the habits of these carriers or disseminators, and of the life-history of the intruders or parasites themselves, there is arising an increasing body of knowledge leading to methods of sure prevention which are even more hopeful than the achievement of cures. With biological science behind him, man is conquering one disease after another.

Hookworm disease, or ankylostomiasis, is the cause of one of the heaviest mundane clouds that have ever rested on the human race, producing in many warm countries the " tropical depression " which travellers, missionaries and employers of labour have often deplored. It is due to several kinds of threadworm (species of Ankylostomum and

Necator) that pass as larvæ through cracks in the skin of bare feet, and burrowing in the body, fix themselves in the wall of the food-canal. They grip firmly by means of hooks beside their mouth and draw blood from the lining membrane. The results are bloodlessness or anæmia, weakness, emaciation, melancholy, lassitude, despair and death. The disease, for so many years a mystery, is now well understood; the intruding hookworms can be readily expelled from the food-canal by doses of carbon-tetrachloride, and further infection can be prevented by theoretically simple sanitary measures, which keep the soil around the village from being diffusely infected with the young stages of the hookworm. Thanks to medical efforts, especially those of the Rockefeller Institute campaign, the incidence of hookworm disease has been checked over vast areas and has been in some places reduced from 25 to 2 per cent. of the population. With patience and goodwill the heavy cloud will disappear; our present point is that the preventive measures are based on a deepening of biological knowledge.

Human progress is mainly due to positive ameliorations—physical, organic and social; but it is no small gain when handicaps are removed, and the heaviest of all handicaps is disease. So let us take another instance of Biology to the rescue. In various warm countries, such as Egypt and Japan, a painful and serious disease known as "bilharziasis" is rife. Every third child born in Cairo becomes infected with bilharziasis and in some places every third adult has the disease, which is due to various species of a very peculiar worm (Schistosomum) in the order of Trematodes, to which the liver-fluke of sheep also belongs. The microscopic larvæ, like transparent forked threads, enter man through cracks or abrasions on the skin, and occasionally on the lips and lining of the mouth. Passing through the body, many of them take up their abode in the bloodvessels of the small intestine and in the region of the kidneys and bladder. This varies with the different species of Schistosomum. They produce minute hard-shelled eggs, each with a lateral or terminal spine (according to the species), and the pressure of the multitudinous sharp spines on the walls of the bloodvessels causes great pain. The minute eggs are passed out from the kidneys or the food canal, according to the species; and, unless precautions are taken, they may readily find their way into water-pools. There they hatch into microscopic larvæ, which enter various species of water-snail such as Planorbis and Isidora, and there continue their development somewhat in the same way as the young stages of the liver-fluke develop inside the little water-snail, Limnæus. From the water-snail there emerge other more advanced larval stages, minute, threadlike and free-swimming, called cercariæ, and these bore into the skin of children who paddle or bathe in the water, or into the hands of washerwomen, gardeners and the like. Apart from man, their host is some aquatic mammal such as a water-vole. The life-history which we have just outlined was elucidated by Major Leiper during the War, when bilharziasis often occurred among our soldiers in Egypt, and his biological investigation threw immediate light on prevention. Contamination of water-pools may be prevented; children may be forbidden to bathe there; water-snails may be collected; snail-eating birds may be encouraged; the aquatic plants that the snails browse on may be

destroyed; the larvæ on watercress and the like are killed by dissolving tabloids of sulphate of soda, and they die in thirty-six hours in water that is kept quite still. In these and other ways Biology has shown man how to conquer a serious disease, a handicap to progress.

III. Biology and Life's Difficulties

There are many indications to-day that we are at the beginning of a new era—the era of biological control, when for the first time on a large scale mankind is turning to the life-sciences (in addition to Medicine), and saying: "Show us what you can do for us in the way of betterment." Sporadically in recent years Biology has been consulted by physicians, educationists, practical men, and even statesmen; there are signs, we think, that it is soon going to be appealed to more generally by educated humanity, seeking life more abundantly. Let us illustrate our meaning.

In civilised society—and that is no modern affair—there is a sorry frequency of sex-pathology, taking many forms. What should be the finest expression of our life is too often ugly and besmirched. Often what should be highest happiness becomes an obsession or repression, the source of unhappiness, it may even be of disaster—physical, mental and moral. In place of the old tribal instructions and initiations, though these had their morbidities, too, there has been for centuries a taboo of the subject except in salacious form, and adolescence is allowed to steal in on life like a thief in the night.

But what can Biology do to help? It can present the normal facts of sex in impersonal and scientific form. It can give to much that is puzzling an intelligible interpretation; for instance, by explaining the rôle of the sex hormones. These hormones or internal secretions, as we have already explained, are potent chemical messengers which are produced in ductless glandular tissue and are distributed by the blood throughout the body, exciting, or sometimes hindering, activity in particular structures. The sex-hormones from ductless glandular tissue associated with the reproductive organs are produced very markedly at adolescence, and evoke changes in body and mind which were mysteries till the rôle of these chemical messengers was discovered.[1] Biology can also trace with great advantage the evolution of sex through the animal kingdom and show how the path of progressive evolution has been one on which a primarily physiological urge becomes an æsthetic attraction, and rises from fondness by psychical refinement to lasting love. It can also show how self-indulgence is apt to lead to tyrannous habits and even to nervous deteriorations; and so on and so forth.

This is but a single illustration, for in many directions Biology is now mature enough to give man definite counsel, not to replace, but to supplement the older controls of an ethical, traditional and religious character. Biology can advise as to habit-forming, diet, stimulants, improved environment, sleep, play, population and the culture of existence in general. When its advice is widely asked and taken a new era will have dawned.

[1] For a fuller treatment of this subject, see the Article on *Sex*, p. 283.

IV. The Cultural Value of Biology

The utilitarian value of Biology is being increasingly recognised, but can the same be said for its educative or cultural rôle ? As a recreation the old-fashioned Natural History, now rising into Ecology (the science of habits, habitats and inter-relations), may perhaps be holding its own; but there are at present few enthusiasts for the educational value of the biological sciences. This is partly because these do not afford that resoluteness of discipline to be found in the study of the exacter sciences, like mathematics, chemistry and physics. But another reason, we fear, is that we live in a dominatingly mechanical age, and " as is the world on the banks, so is the mind of man." The fact is that man needs biological culture more than ever before.

(*a*) To the biological sciences we owe many mental pictures that are treasures. The Natural History and Botanical picture-gallery is full of masterpieces, such as the world of the great oceanic abysses, or the woods of the Yosemite valley.

(*b*) The study of Animate Nature is an æsthetic education. Everywhere there is beauty—of form, of colouring, or of movement; easy beauty of bird and tree, difficult beauty of serpent and sea-wrack; conspicuous beauty like the peacock's tail, hidden beauty such as the internal zoned architecture of a sea-urchin's spine. And while science is in itself quite unemotional, it feeds the æsthetic sense, and the more we know of the biological aspect of withering leaves, the more we enjoy the autumnal woods.

(*c*) The biological sciences open our eyes to the Drama of Life, and excite an ever-increasing interest in things that angels might desire to look into—life-histories, linkages, endeavours, subtleties, comedies, tragedies, anticipations. Animate Nature is an inexhaustible well of surprises, which make for the enrichment and enhancement of man's life. It is not that they are curiosities of Natural History, quaint pieces of information ; it is rather that they give us glimpses into the heart of things. They suggest Walt Whitman's exclamation : " Prais'd be the fathomless universe, for life and joy, for objects and knowledge curious."

(*d*) There is an incalculable cultural value in the great facts and ideas of Biology—the ascent of life, the pulse of evolution, the web of inter-relations, the ceaseless circulation of matter, the development of the embryo, the trajectory of each life-history, the long inclined plane of animal behaviour, rising to remarkable freedom of mind in man.

(*e*) As a fifth contribution to Culture may be ranked the array of brain-stretching problems which biological study provides. It is not to be compared with mathematics for intellectual gymnastics, yet Animate Nature is a " Euclid " by itself, tending to develop sound judgment. Who can tell us why a cell divides into two, what the fertilisation of the egg-cell really means, how embryonic differentiation comes about, or the true inwardness of sex ? Biology bristles with unsolved problems ; the realm of organisms is full of marks of interrogation.

(*f*) Finally, it must be recognised that sojourning with living creatures in Nature brings home to us the deep impressions of growing, multiplying

and developing, of varying, inheriting and sifting. These form indispensable parts of a well-educated man's mental furnishing, and they cannot be replaced by anything else. The fact is that life-lore is essential if our life is not to be impoverished. No doubt many able-minded men and women have got on well without knowing any Biology, but how much more they might have been with it!

V. *Biology as a Foundation for Eugenics*

Those who cherish ambitions for mankind are unanimous in including healthfulness of race—healthfulness in the widest sense, meaning clear-headedness and goodwill as well as sound physique. The ideal means much more than a reduction of disease, though that always counts for much; it implies positive health, expressing itself in vigour, resisting power, initiative and joy. No one can look around to-day and remain complacent: so many are diseased in body and mind; so many are victims of their appetites; so many live at a low level of healthfulness, with no more than sub-health; and so many show little trace of beauty or of happiness. The endeavours to raise the standard of racial fitness in our civilised communities are called eugenic, in opposition to dysgenic tendencies which make towards the deterioration of the human breed. Our present point is that the foundation of sound eugenics must be sound Biology.

It is not suggested that all man's troubles are due to causes which more Biology would remedy, for some are in part due to evils inherent in the social system that enmeshes us; others are due to deficiencies in imagination, kin-sympathy, and goodwill; others are due to our liking for lower pleasures and for lines of least action; and others again to our mis-education, often including a dismal ignorance of the history of our race. It would be a fallacious "biologism," akin to a fallacious "materialism," to think that applied genetics alone will save us in our sea of troubles. There must be eupsychics, and much more, as well as eugenics.

Here at once we see the eugenic value of Biology, since the biologist is always seeing the three sides of his prism:—Organism, Function and Environment; the Living Being, its Doings, and its Surroundings. These obviously correspond to the three chief concepts or co-ordinates of the sociologist: Folk, Work and Place—Le Play's *Famille, Travail, Lieu.* But, even more than the sociologist, the biologist is habituated to considering every problem in these three indissoluble aspects, and is therefore saved from the fallacy of thinking that secure progress can be made by working along one line only. There must be Eutopias and Eutechnics if Eugenics is to have much chance.

Similarly, the biologist, more than any other investigator, is familiar with the idea of the Unity of the Organism, not merely as an orchestral harmony, "many members in one body," but as, in its higher expressions, alternately BODY-mind and MIND-body. Thus the biological eugenist will never forget the necessity of Eupsychics; his ideal is *mens sana in corpore sano.*

One of the oldest ambitions in the world is to have a fine family, and eugenics is the modern scientific expression of this ambition, which has become in modern times sadly more difficult of fulfilment. There has

been, for too long among too many people, a disregard of the need for persistently selecting towards health, and for avoiding as far as may be a sowing of tares along with wheat. It comes to this, that Biology is needed as a broad foundation for eugenics; we require not merely a deeper knowledge of heredity, of the influence of environment, of the rôle of nurture in general, but a deeper insight into the subtle ways in which Animate Nature has wrought out its exuberance of evolving life.

VI. Ethical Value of Biology

To envisage the ascent of life is to discover a solemnly long series of experiments with life—a book in which man may find guidance. Not indeed clearer or better guidance than he can find elsewhere, as in the history of his race, yet if he reads aright a light to his feet and a lamp to his path. Thus there is the great ethical lesson of the struggle for existence, that things of value require to be struggled for. It is easy to make too much of the cruder forms of the struggle for existence, of Nature red in tooth and claw with rapine, of the Hobbesian warfare—each for himself and extinction take the hindmost; but more accurate Biology discloses not only the large proportion of time and energy involved in parental care and mutual aid among kindred, but the great rewards that have gone to those animals that show other-regarding endeavours and what amounts to self-subordination. In the success of birds and mammals we see what has been called "a materialised ethical process"; for such activities as are illustrated by the long-tailed tit's gathering of 2,379 feathers to quilt its nest, or by the prolonged nurture, protection, and education which the mother-otter gives her cubs, have Survival Value just as much as those which are seen when the golden eagle lifts the grouse, or the tiger launches itself on the young deer. There was genuine insight in giving to the highest class of animals—to which man is affiliated—the name of mammals, so obviously suggestive of mothering.

It is not suggested that animals are ethical agents, for there is no warrant for crediting them with general ideas, but the point is that there has been a long evolution of the incipient virtues, the raw materials of good conduct, such as courage, affection, control and sympathy; and many animals are morally admirable, along certain lines at least. But besides the *occurrence* of the primary virtues among animals, we must recognise that they have been rewarded in the course of Organic Evolution with survival and with success. There is an evolution of ethics, but there is also an ethics of evolution.

No doubt there are seamy sides in Animate Nature, such as parasitism; and lurid warnings, such as may be seen without a microscope in the servile state of ants and bees, and with one, if we inquire into the fatigue-degeneration of the brain of the short-lived worker-bee; yet on the whole it must be allowed that Animate Nature is condemnatory of the unlit lamp and the ungirt loin. There are some difficult cases, but Animate Nature is almost always for health, unless man interferes with the conditions of life, as in domestication and cultivation. It is easy enough for anyone so inclined to travesty our thesis, and to say that the very best to be found in Animate Nature is a pageant of lusty animals; but that is not

accurate. The higher creatures are psycho-biological beings, as we ourselves are; and proud man has often much to learn from the courting of birds. Moreover everyone who has reflected knows that our degree of healthfulness from day to day is often a subtle and rigorous criterion of our morals; and Animate Nature is almost all for health.

VII. Biology and Philosophy

Our last question is the most difficult: How does Biology affect man's synoptic (philosophical and religious) outlook on the world as a whole? There are many uncertainties in biological science, especially as regards the innermost secret of that kind of activity that we call life; the correlation or regulatedness that makes the organism a "whole"; the true inwardness of sex, of development and of variability; and the perennial problem of the relation between the mental and the bodily aspects of the organism—the psycho-biological and the bio-psychological. But there are great certainties as well. Thus (*a*) There is general agreement that in some way or other organisms transcend mechanisms; there is an autonomy of Biology. Again (*b*) In some way or other the living creature is only intelligible as a historic being; that is to say, in Clifford's words:—

> "It is the peculiarity of living things not merely that they change under the influence of surrounding circumstances, but that any change that takes place in them is not lost, but retained, and, as it were, built into the organism to serve as the foundation for future actions."

Living implies both individual and racial enregistrations; and these are certainties, though it is not easy in either case to explain *how* the engraining is effected.

(*c*) It is also characteristic of organisms that each is affiliated to the past and normally parental to the future. In other words, living creatures have to be thought of as links in a hereditary chain, for heredity is the relation of genetic continuity between successive generations. Ever present is the child of the past and the parent of the future. This is, of course, an old idea; but it has become more incisive since Galton and Weismann disclosed the fact of the continuity of the germ-plasm—that individuals are, as it were, the deciduous pendants of an undying lineage of germ-cells. The parent organism, especially the mother, is obviously the producer of the offspring; yet, as Galton said, it is almost truer to say that the parent is the trustee of the germ-cells, which will eventually develop into offspring. As Weismann put it:—

> "In each development, a portion of the specific germ-plasm contained in the parent egg-cell is not used up in the construction of the body of the offspring, but is reserved unchanged for the formation of the germ-cells of the following generation."

In a deeper way than even Darwin recognised, there is a hereditary *continuity of generations*. The modern biologist thinks of the organism as a living link between past and future.

(*d*) Another fundamental idea in the modern biological view is that the organism must always be thought of as functioning in particular surroundings which, in turn, condition it and react upon it for good and ill. The three sides of the prism of life are, as we have already said, Organism, function and environment; but at times we must read them the other way round and give the capital letter to the environment or system of surrounding influences—Environment, function, organism. These are the three co-ordinates of Biology, inseparable except in scientific analysis. Since the everyday functions, say, of irritability and contractility, nutrition and respiration, are wrapped up with the very idea of organism, which becomes an empty name without its functions, it may be clearer to use the word " functionings " to denote the organism's actions on its environment. Thus the three sides of the biological prism are Organisms, Functionings and Environments, corresponding to the sociological co-ordinates : Folk, Work and Place, in terms of which every sociological fact must be considered. As Professor Patrick Geddes has put it, living is a moving equilibrium between O->f->e and E->f ->o ; and similarly for the social life of mankind, Fk->w->pl and PL->w->fk. Or in ratio form : $\frac{O\ f\ e}{E\ f\ o}$ and $\frac{Fk\ w\ pl}{Pl\ w\ fk}$; and the biological ratio is, as it were, parallel with the sociological.

But (*e*) the relation of an organism to the past is more than that between offspring and parents, descendants and near ancestors : it is a racial relation to an older, usually more generalised, stock. A modern horse has an immediate pedigree, but it is also a descendant of remote ancestors with three or four digits, instead of the single finger or toe which the modern type bears on each limb. Just as all our modern breeds of domesticated pigeon are known to have been derived under man's care from the wild rock dove, *Columba livia*, so the thousands of wild birds are all traceable to some ancestral extinct bird more than hinted at in the first avian fossil, Archæopteryx, whose structure proclaims that it, in turn, was derived from a stock of extinct reptiles. Every organism is an antiquity with a long pedigree, leading back to simpler or more generalised ancestors, except in cases where evolution has been retrogressive or degenerative, as in the case of parasitic and easy-going types, whose ancestors were *less* simple. Moreover, we must think of organisms as not merely outcomes of evolution, but as themselves, in many cases, evolving here and now. Variations are still emerging ; selection is still in operation ; new adaptations and even new species are still arising for better or for worse. The biologist is always saying to himself, in Hegel's words : " Becoming, Being, and Having Been."

There can be no synoptic or philosophical view of the world which does not include living creatures as part of the picture, and our first point is that these must be thought of as (*a*) Transcending mechanism ; (*b*) Enregistering experience ; (*c*) Affiliated to their immediate progenitors ; (*d*) Functioning in particular environments ; and (*e*) Evolved from simpler ancestors and in many cases evolving still.

But while it is of great importance to realise these five characteristics of living organisms, they do not exhaust the richness of reality. As Robert Louis Stevenson said, " Science writes of the world as if with

the cold finger of a starfish; it is all true, but what is it when compared with the reality of which it discourses?"

Living beings are always in flux, always breaking down and always being built up again. Their essential constituents are proteins and other carbon-compounds, always being burned or oxidised, and yet the unities we call organisms have their fit symbol in the burning bush of old, for they are not consumed for many a day. Throughout the world of life there are similar living stones and mortar—protoplasm, the physical basis of life; but while this makes the whole of Animate Nature kin, the complementary fact is *specificity*, for each species or definable kind is itself and no other. Each has some particular protein, different even in nearly related species, such as fox and wolf, horse and ass. This individuality or idiosyncrasy is one of the marked differences between living organisms and non-living things. Thus we have a first triad of qualities: persistence amid change, ceaseless down-breaking and up-building of colloidal protoplasm, and specificity of proteins for each particular form of life. Colloidal means that the material in question, whether living or not living, consists of innumerable ultra-microscopic particles or unmixing droplets suspended in a fluid; and its importance is partly because of the multitudinousness of the minute surfaces, on which physical and chemical changes may take place. A drop of protoplasm may be compared to an archipelago of many islands on whose multitudinous coastlines there is great opportunity for fishing and trading!

A second triad of qualities characteristic of living beings may be summed up in three words—growth, multiplication and development. Everywhere in the world of life we see growth, usually accomplished by the division of cells; and it differs from the accretion-growth of crystals in being from the inside outwards, and because the material used is in most cases very different from that composing the organism. The grass grows at the expense of air and water and the salts of the soil; the foal grows at the expense of the grass. But a crystal cannot grow except from a solution of the same kind of material, or occasionally from a different kind of material that has the same crystalline form.

It is normal for a full-grown organism to multiply, and in most animals this occurs when a definite size, *the limit of growth*, is reached. In ways that vary from type to type, the plant or animal becomes a parent; and soon there is a succession of generations. In the non-living world there is no counterpart to multiplication unless we point to a nebula giving rise to a double star, or to a molecule dividing into two molecules, or to a radio-active substance giving off helium particles—and these are rather far-fetched analogies.

Not less familiar, and not less striking when one begins to think about it, is the process of development, wherein a detached portion of the adult, or a liberated germ-cell, proceeds to reproduce an entire organism. Out of the apparent simplicity of the egg-cell there develops the obvious complexity of a young creature; from a clear drop on the top of the yolk of a hen's egg there develops a chick. From a fragment of a begonia leaf there develops an entire plant—flower and all. The latent becomes patent, the apparently homogeneous becomes the obviously heterogeneous, the invisible becomes visible. Such is development.

The third triad includes two characteristics to which we have already referred—the enregistering of the past in the present, in such a way that the future is affected (Bergson's *durée*), and the power of evolving, giving rise to something new under the sun—but also a third feature, the power of effective response, of purposive (rising to purposeful) behaviour. In animals especially, where mind begins to be emancipated, this quality of endeavour stands out clearly; but all through the world of life there is purposive agency. Here the symbol of the organism is not the burning bush but the bent bow.

Our point, then, is that living creatures, which must be included in our philosophical picture of the world, show an integration of qualities. The first triad includes :—

1. Persistence amid incessant change;
2. The down-breaking and up-building of colloidal protoplasm; and
3. Specificity.

The second triad includes :—

4. Growth;
5. Multiplication; and
6. Development.

The third triad includes :—

7. Enregistration;
8. Purposive behaviour; and
9. Evolvability.

An appreciation of these nine characteristics will certainly save us from an easy-going or a commonplace view of organisms, yet the total impression is too cold and academic. Let us seek, therefore, to envisage the wonder of life more vividly.

THE WONDER OF LIFE

(I) We are impressed by *the abundance of power* in the universe, from the movements and internal activities of the heavenly bodies down to the fierce little world within the complex atom, and between these extremes of the infinitely great and the infinitely little are the powers of life—the power of winding up the living clock almost as fast as it runs down, the power of an open-sea fish, whose muscles are more efficient as energy-transformers than are the engines of the *Mauretania*, the power of an eagle in the air, far surpassing any flying machine; and life's power of multiplying itself so that in a few hours an invisible microbe may become a fatal million. Most of the physical and chemical non-living clocks in our cool corner of the world, such as a fragment of radium with its extraordinary output of energy, are running down; but every living organism succeeds in winding itself up for days or for years or

for stretching cycles of years. From hour to hour it ripes and ripes, long postponing the evil day when at length it begins to rot and rot, as Shakespeare put it. A great river rushing down to the sea, carving its bed and driving many mills, is a fine example of power, but the otter in the river is finer, for it commands its course. Life is a stream that seems often to flow uphill; its power is insurgent. As Goethe said, animals seem very often to be attempting the impossible and achieving it. The water-spider, though belonging to a thoroughly terrestrial stock and breathing dry air, just as we do, has chosen to spin a web in the moorland pool. The migratory birds annihilate distance and know no winter in their year. The bat is a true mammal, yet it has learned to fly. Living creatures are marked by extraordinary insurgence, and that is a characteristic part of the picture.

(II) The fact of multitudinous life, we are urging, has to be included in our synoptic picture of the universe, just as we must take account of the numbers and the immensities of the stars. As Spenser said in *The Faerie Queene*:

> " For much more eathe to tell the starres on hy, albe they endlesse seem in estimation, than to recount the sea's posterity; so fertile be the floods in generation, so huge their numbers and so numberlesse their nation."

Just as the modern astronomer, becoming philosophical, tells us that the heavens declare themselves as the thought of a Supreme Mind, transcendently mathematical, so a naturalist, familiar with the multitudinous variety of living creatures, is often given to think of a Supreme Mind, transcendently artistic, and loving life for its own sake. We see the world-floor, the great studio of Animate Nature, strewn with sketches, each a little masterpiece. So Tennyson turned away from peering into the crowded life of the brook, with the exclamation : " What an imagination God has!" In any case one gets the impression of endless resources in the creative evolution of individualities.

Over two thousand years ago Aristotle knew about five hundred different kinds of animals, and now the list of the named and known, still far from complete, includes twenty-five thousand Vertebrates, and a quarter of a million (some zoologists estimate twice as many) Invertebrates.

What prodigality of unique species, for each is itself and no other. As St. Paul said:

> " All flesh is not the same flesh, but there is one kind of flesh of men, another flesh of beasts, another of fishes and another of birds."

One can often identify a bird from a single feather that it drops from its wings; one can often tell a fish from a few scales. Everywhere there is *specificity*.

(III) Another feature is *intricacy*, for everyone knows that he is fearfully and wonderfully made. Our body is built up of millions, billions, trillions of cells or unit corpuscles of living matter. The average man has

twenty-five billions of oxygen-capturing red blood corpuscles, which if spread out would occupy a surface of 3,300 square yards. Even more significant is the fact that he has in the cerebral cortex of his brain, the home of the higher intellectual activities, over nine thousand millions of nerve-cells, that is to say, more than five times the present population of the globe—surely more than the said brain of the average man as yet makes use of! And our impression of intricacy grows when we realise that these neurons are connected to one another by branching processes or dendrites which make multitudinous inter-linkages possible.

And again each cell is a microcosm, for within the colloidal contents or cytoplasm (in part consisting of true living matter or protoplasm) there floats a kernel or nucleus which contains forty-seven (in woman forty-eight) rodlets or chromosomes, each with a bead-like arrangement of smaller microsomes, and so on till we reach the invisible (yet not unmeasurable) "genes" or hereditary "factors"—the initiatives of the various distinctive "unit-characters" of the body. We see that the nucleus of the cell is a little world in itself, and the cell may also include centrosomes, mitochondria, chromidia and so forth, with untold complexities of interaction. And a remarkable fact is that when a typical growing cell divides, there is a meticulous halving of everything—chromosomes, centrosome, mitochondria—everything. By a complicated sequence of manœuvres in all ordinary cells of plants and of animals, it comes about that each daughter-cell is a replica of the parent-cell.

(IV) Also to be taken account of is the world-wide *adaptiveness* of living creatures. Every complex organism is a bundle of fitnesses. Some are no doubt more striking than others; thus, as a great biologist once said, if one takes away all the adaptations from a whale, what is there left? In fact, wherever there is intricacy of structure or subtlety of function in plant or animal, adaptations abound; and while we can no longer agree with Paley in directly arguing from these to a Divine Artificer, we cannot ignore one of the largest facts of life, that living creatures are adaptive through and through. The creative institution of the Order of Nature was evidently such that more and more perfectly adapted organisms have emerged in the course of evolution.

(V) Apart from parasites, which often establish a *modus vivendi* with their host, there is very little trace of disease in Wild Nature, though it may become rife when man interferes, with a grasp more greedy than skilful. And what strikes the trained observer as characteristic of Wild Nature is more than the rarity of constitutional, functional or environmental disease; there is an exuberance of *positive health*. No doubt there are parasites, living a drifting life of ease; degenerates that have settled down into easy-going sedentariness; and retrogrades that have, for various reasons, lapsed from the level reached by their ancestors; but these are exceptional. What is characteristic of Wild Nature is the lit lamp and the girt loin, the vigour of positive health.

And if disease be defined as disintegrative disturbance of the well-balanced metabolism or chemical routine of the body, we can understand why it should be so often associated in mankind with ugliness, whereas harmonious orderliness of life makes for beauty. Some animals fail to

please our æsthetic sense, which is often over-conventionalised, and thus we invent popular names like "devil-fish" and technical names like *Moloch horridus*, but the artist is delighted with both these creatures. Grotesque they may be, but not ugly. Just as with pictures, so among organisms there is difficult as well as easy beauty. Thus anyone can admire the peacock's tail: it needs a Ruskin to perceive the sinister beauty of the snake. Not only is organic beauty an expression of orderly and integrative vital processes, it often bears the marks of the animal's strenuous, graceful and eurhythmic movements; and sometimes we may go the length of saying that beautiful features are, as the poet discerned, "chiselled from within," especially when there is a strong emotional life, as in birds. But the point is the pervasiveness of beauty among living creatures. It is part of the picture, as real as metabolism. Surely Lotze was right, that it is of high value to look upon beauty not as a stranger in the world, nor as a casual aspect of certain phenomena, but as the "fortunate revelation of that principle which permeates all reality with its living activity."

(VI) Not much can be said in regard to the mental aspect of the life of the lower animals, and still less when we turn to plants; and yet it is impossible, we think, to do anything like justice to the behaviour of higher animals without crediting them with minds that count. It is not a question of our being generous or parsimonious, the point is whether we can give an adequate description of the higher reaches of animal life on apsychic lines. Excepting the extreme behaviourists, science agrees with common sense in declaring this impossible. There are animal "minds" that count for something; and we cannot make sense of what we see unless we credit the animal with an inner subjective life of feeling, imaging and purposing—analogous to our own. And just as we watch every day the development of mind in the individual child, from the simplest and vaguest expressions of infancy to the epiphany of lively intelligence, joyous emotion and eager will, so looking at racial evolution we must search among the lower animals for the early stirrings of mind. The biologist is not likely to forget Spinoza's warning, that we must not be too quick to decide what the body, *as body*, may not do; but there is a growing array of facts, such as the modern study of the Anthropoid Apes, pointing in the direction of more Psycho-biology, as well as more Bio-psychology. In other words, the biologist is finding it necessary to study the higher animal as a MIND-body and as a BODY-mind alternately. No one wishes to over-emphasise the psychical aspect of the lower animals or of plants, since it is obviously difficult to give content to the concept at these low levels; but if there is continuity in organic evolution we must expect to find the dim analogues of mind even in the Protozoa. "Mind" or "sentience" is probably conterminous with life itself.

(VII) The crowning wonder of life, giving significance to the whole picture, is the fact of Organic Evolution. We have already mentioned evolvability as one of the nine characteristics of organisms, but we must not lose the drama in the doctrine. It is not merely that birds evolved from reptiles, these from amphibians, and these from fishes; the concept of Organic Evolution is much more than a system of pedigrees. We must

have some vision of the succession of achievements, such as the first body, the first sex, the first limbs, the first brain. What acquisitions are suggested by the words—blood, eye, voice, "warm-blooded," viviparous? We must have some picture of the gradual peopling of the wide, wide world by plants and animals; of the repeated colonisations of the dry land, and the far-reaching consequences of each; and of the insurgent possession of every niche of opportunity. We must imagine the changes of the world stage in successive geological periods, and how these, not least those of climate, involved new motives in the drama and new pitfalls as well. There has been an evolution of sieves as well as of material to be sifted. Nor can we afford to ignore the gradual weaving of the web of life, the linking of living creatures together in subtle interrelations. This is characteristic of life, that it forms a *systema naturæ*, which serves as a subtle sieve for new departures or variations, and also tends to lessen the risk of retrogression. Animate Nature is a fabric, with a changing pattern; and man insists on sharing in the weaving.

To sum up: our argument is that the picture of organisms that must form part of our synoptic or philosophical view, should include some appreciation of the power of life, the multitudinousness of specific individualities, the astounding intricacy, the pervading fitness, the practical omnipresence of beauty, the interactions of mind and body, and the dramatic character of Organic Evolution.

DESCRIPTIVE NATURALISM

The biologist seeks to describe, as simply and tersely as possible, what happens in Animate Nature and in individual organisms, and he does so in terms of factors which are experimentally verifiable in the system of things which he observes. His universe of discourse includes the minds of animals, so far as these are demonstrable, but it does not include anything mystical or transcendental. One of the greatest of naturalists, Darwin's magnanimous colleague Alfred Russel Wallace, went beyond Biology and beyond science when he postulated special "spiritual influxes" to account for various "big lifts" in evolution. That was departing from the method of *descriptive naturalism*, which keeps to empirical formulæ, trying to account for the facts of life, in the case of Biology, in terms of the factors known to be resident in organisms and their surroundings. *What are these factors?* They include:—

(*a*) Chemical and physical processes, operative in and around organisms;

(*b*) Qualities of protoplasm that remain at present in greater part irreducible, such as irritability, persistence or inertia, growth and development; and

(*c*) Resident mental or psychical activities, when these are convincingly recognisable as at work.

It must be clearly understood that scientific naturalistic *description* does not imply what is called philosophical naturalism, which denies the validity of all transcendental or spiritual *interpretation*. For while science

answers the questions *What?* *Whence?* and *How?* it never even asks the question *Why?* In other words, science does not raise the philosophical or religious question of the meaning, significance or purpose behind the world of the measurable. It does not inquire into the original Beginning or the Essence of things. But what the biologist has to aim at in this connexion is the working out of an empirical description which will be as exact and impersonal as possible, and verifiable by all normally constituted minds who can use the methods. Of all science, but of Biology in particular, it must be understood that it is a partial and abstract inquiry, based on observational and experimental methods devised to detect and measure (or register) certain orders of fact, and these only. As we have often said, the biologist, as biologist, dredges in the sea of reality with nets of a certain kind of mesh (his biological methods), and is naturally restricted to the capture of certain kinds of fishes. As a man he may appreciate beauty; as a biologist he does not catch it except in rare cases; *e.g.*, when it operates as a factor in the courtship of birds. More generally, if he has arranged the meshes of his net so that they will only catch metabolism, he cannot expect to discover Mind in his sea. None the less, he may be well aware of it, and thus becomes psycho-biologist. Of course the biologist cannot be sure that his science has as yet come to know all the factors operative in Animate Nature, but he should none the less remain radically opposed to every attempt to eke out empirical factors with subsidies from transcendental treasuries.

VITALISM

The biologist seeks to avoid all "isms" except organism. He has the difficult task of steering between a metaphysical Scylla and a materialistic Charybdis. His only safety is to keep close to the facts of the case, and that is easier said than done. On the one hand, it is plain that there are chemical and physical processes always going on in the living organism, and to do justice to these—a fruitful pathway of discovery—is what Comte called "legitimate materialism." Living matter is in a colloidal state, and much that goes on in the living cell must be described as far as possible in terms of the properties of colloids. Innumerable ultra-microscopic particles and unmixing droplets of proteins and other carbon-compounds are suspended in a fluid medium, and their surfaces, very large in proportion to the total volume, afford vast opportunity for physical and chemical changes. We may repeat our useful metaphor, that the invisible particles, whose refractive haloes are sometimes demonstrable in the strong light of an ultra-microscope, may be compared to the islets of an archipelago, whose coast lines, large in proportion to total area, afford opportunity for much trading. Similarly, the biologist must take account of the surface-tensions, the capillarities, the absorptions and adsorptions, the diffusions and so forth, that are observable in the living. Much is to be learned from bio-physics and bio-mechanics, yet the biologist finds that organism transcends mechanism.

So with bio-chemistry, a very illuminating contact of two sciences. In the living body there is an interplay of oxidations, reductions, hydrations, dehydrations, fermentations and so forth; and the science of the living

body cannot afford to ignore any one of them. Yet the biologist clings rightly to the autonomy or independence of his science, since he does not find it possible to give an adequate description of the behaviour, the development, the evolution and the other outstanding features of the organism in terms of bio-physics and bio-chemistry. Abstracted corners may be so described, but no *complete vital phenomenon* has as yet found adequate chemico-physical description; there is some integration or regulatedness or registration of previous individual and racial experience, a purposiveness which is beyond purely chemical and physical formulation—indispensable as these are. Such familiar occurrences as the winking of an eye do not in the present state of science admit of being satisfactorily described in terms of chemistry and physics, but require, in addition, distinctively biological concepts, which might be called organismal, such as growth, development, enregistration and integration. Our position, which may be technically called "methodological vitalism," differs from positive vitalism in not postulating any "vital force," "entelechy," "élan vital," or other *x*, but in simply saying that, as a matter of fact, organisms require for their scientific description certain biological concepts or categories which are at present irreducible. It differs from the mechanistic position in maintaining that the organism, even when it has no demonstrable mental aspect, is more than any mechanism. A new aspect of reality emerged when life began. In other words, the first organisms were new "wholes," new syntheses, which made the world new.

PSYCHO-BIOLOGY

When we come to know the behaviour of living creatures intimately we make two discoveries that are at first sight somewhat divergent. We find that many activities that seemed, to begin with, clever, are really automatic, in the sense that they do not require conscious control. They are reflex, as when the earthworm jerks itself back into its burrow; or tropistic, as when the young eels make steadily upstream all the long spring day; or rhythmic, as when the green Convoluta worm comes to the surface of the sand at the ebb of the tide, and retires again at the first splash of the incoming flow; or instinctive, as when the young spider on its first attempt constructs an intricate web true to type. In the course of Organic Evolution there has evidently been a tendency to enregister in the hereditary constitution ready-made responses to normal circumstances. Care must also be taken to do justice to the individual development of what Pavlov has called "conditioned reflexes," which play an important part in the life of man and beast.[1]

On the other hand, among the higher animals, such as birds and mammals, there are indubitable evidences of intelligence, of putting two and two together, of making a simple inference, of profiting by experience, of "learning" to live effectively. We must use the term *intelligent* when we cannot describe the behaviour without giving the animal credit for "perceptual inference," a sort of picture-logic. And even when the behaviour

[1] These are dealt with in the Article on *Psychology*, p. 329.

cannot be called intelligent, as in a ganglion-less starfish, there may be initiative and experiment, something on a quite different line from enregistered response. But from the amœba, engaged in hunting a smaller amœba, up to the chimpanzee, engaged in joining two bamboo lengths together to make a rod long enough to reach a coveted fruit, there is evidence of mentality; and when it does not take the form of experiment, imaging or ideation, it may be expressed in joy and in the bent bow of purpose. Apart from the extreme behaviourists who maintain that mental activities are only the foam-bells on the stream of nervous activities or neuroses, all naturalists are agreed that animal behaviour is shot through and through with a subjectivity that operates as a *vera causa,* whether it be the emotion of the nightingale or the well-laid schemes of the resourceful otter. Even in the very thoroughgoing instinctive behaviour of ants and bees there are passages which seem to demand flashes of intelligence.

Among higher animals, the higher mammals in particular, there is an undeniable mental or psychical life analogous to our own, with inferences, emotions, purposings and the like comparable to ours. Yet there is no warrant for crediting animals with " *Conceptual* inference " or experimenting with general ideas. They may rise to intelligent reasoning, but they have not Reason in the sense of conceptual inference. In the same way, while many birds and beasts have words, none can be credited with language in the strict sense—the expression of judgments by means of socially imitated sounds. These two prerogatives, Reason and Language, give man a position higher than that of animals, and it is also evident that in mankind the *social heritage* of extra-organismal gains—as in literature, art, institutions and permanent products—plays a very important part, supplementary to that of the *natural inheritance,* enregistered in the germplasm. Among animals there are hardly more than adumbrations of this social heritage, but some of these, notably the ant-hill and the beehive and the termitary, are of surpassing interest. But our present point is the simple one, that mental or psychical activity, which is such a powerful stream in Man, is more or less recognisable in many animals, even if it has not become more than a slender rill. If it were not so, Man would appear as a discontinuity in Organic Evolution, and the drama of animal life would appear as a magical puppet-show. However the fact may be expressed, the mental activity in a dog or a horse is as real as the metabolism, the psychosis as real as the neurosis.

The progress of biological research on the two sides of neurology and ecology has shown very clearly the closeness of the inter-relation between the neural and the psychical. The mind is " thirled " to the body, and the body is thrilled by the mind. Good news helps digestion ; strong circulation helps clearness of thought. The various grades of chloroforming correspond to the stoppage of mental currents at successively deeper levels. As the body develops so does the mind ; and a thyroid deficiency may spell disaster to the latter as much as to the former.

Some biologists of distinction picture the mind as a musician playing on the instrument of the body (a dualistic view) ; others of equal distinction, think of mental activity and nervous activity as two inseparable aspects of one reality—the life of the organism, which has two inseparable

sides like the inner concave and the outer concave surfaces of a dome (a monistic view). Many other biologists regard the perennial problem as a limiting one for human intelligence as far as that has yet developed. It is for the philosopher to help the biologist to ask aright the question of the relation between "Body" and "Mind"; but it is for the biologist to keep to the facts of the case and to make it clear that the organism is very often almost entirely physiological, with just traces of the psychological, while at other times it is conspicuously psychological, with an undercurrent of the physiological. The Yellow Bunting in flight is an extraordinarily dynamic engine or collocation of engines; but it has a mental picture of its home-tree, a picture inspired with tender emotion, and with memories of mating, nesting and parentage. It is not a mere body; it is BODY-mind; its description implies BIO-psychosis. At another time it is singing to its mate; mentality is in the ascendant; it is embodied mind or MIND-body; its description implies PSYCHO-biosis. In using these useful compound words, due to Alexander Bain, it is probably clearest to put the dominant aspect first—BODY-mind in the homing bird, but MIND-body when the nightingale sings.

ORGANIC EVOLUTION

The term evolution is used in so many different connexions that it requires an adjective in front of it to give it precision. Thus in *cosmic* evolution, say, of a solar system, there is no succession of generations nor struggle for existence, as is characteristic of organic evolution. There is *chemical* evolution when uranium gives rise to radium, and radium to lead; but this is very different from reptiles giving rise to birds, or the wild Rock Dove to domesticated races of pigeons. And again, to give only one other example, *social* evolution implies some awareness of past history and some reasoned guidance towards a future, which cannot be said of the evolution of plants and animals. Yet the fact that some higher animals play an intelligent part in their own endeavours indicates the difficulty of drawing hard-and-fast lines and excluding some perception of a goal. Similarly, looking in the other—the physically determined—direction, we recognise the fact that gamma-rays sometimes play a part in evoking organic variations; and we remember that in a series of related species of, say, rose the chromosomes in the nucleus of each cell number 7, 14, 28 and 56 for the different kinds. *Organic* evolution is different from social evolution and from chemical evolution, but it cannot be considered altogether apart, since human society is its climax, and since even the most enminded organism is a collocation of matter and energy in a material and energetic environment. All evolution is a process of becoming, in which the present is the child of the past and the parent of the future, but Organic Evolution may be defined as a process of racial change in a definite direction, in the course of which new forms emerge and may be established alongside of or in place of the originative stock. So the first birds emerged from a reptilian stock. Evolution is a natural process comparable to that by which man has established so many different breeds of poultry from the wild jungle fowl, *Gallus bankiva*, of India, and so many different varieties of wheat from the wild wheat still growing on the shoulders of

Mount Hermon ; but what corresponds to man's sifting and singling is to be looked for and found in the processes of selection and isolation verifiable throughout Animate Nature.

From our present point of view it is all-important that the picture of Organic Evolution which Biology contributes to the philosophical synoptic view should be as accurate as is possible. But it must be patiently kept in mind that the whole inquiry is still very young. It was not till the work of Darwin (1859) and the anticipations of a few precursors that Ætiology began to be taken seriously !

Modern Evolution theory has not advanced in idea very far beyond Darwinism, but there has been a great extension of knowledge (as to heredity in particular), and on some lines a deepened understanding. The central Darwinian theory was based on the following propositions :

(*a*) Novelties, new departures, or variations are of frequent occurrence ;

(*b*) Some of them are hereditarily continued in subsequent generations, and only those thus "transmitted" can have direct evolutionary importance ;

(*c*) Some variations, distinguishing offspring from parents, or the members of one family from one another, are in one way or another advantageous to their possessors ;

(*d*) For various reasons, such as rapid multiplication, limited space and food, the changefulness of the callous environment, and the insurgence natural to vigorous organisms, there is a manifold, unceasing, intense, and often very subtle struggle for existence ;

(*e*) In the course of this struggle for existence, when organisms come up against environing difficulties and limitations, there is a process of selection which favours the possessors of the variations that are relatively advantageous in the struggle, and tends to eliminate, quickly or slowly, those that are without them ; and

(*f*) There may also be factors securing some form of isolation for new departures, so that they tend to breed together, thus stabilising their advantageous features. A simple case of this is when new varieties on a peninsula are insulated by some geological change.

In short, the central ideas of Darwinism are : variation, heredity, struggle, selection and isolation ; and modern ætiological research has not yet disclosed any other factors in organic evolution. But evolution theory is evolving—it would be strange if it did not—and we wish to conclude this outline of the biological contributions to philosophy by noticing a few of the post-Darwinian steps that seem to be particularly progressive.

As Regards Variations

One of the central problems of Biology is the origin of the new, for it is by the sifting of newnesses or variations that the ascent of life has come about. In other words, variations or mutations supply the raw material of evolution ; and this has been for the most part progressive or integrative, though from time to time, in diverse types, retrogressive and degenerative,

as in the familiar case of parasites. One of the things we are tired of hearing is that Darwinism accounts for the survival, not for the arrival of the fit; but Darwin was quite clear that Nature's sifting or Natural Selection operates on the novelties or variations that are submitted to it, and these are of very frequent occurrence in Nature. Natural Selection prunes the new shoots on the *arbor vitæ*, but neither Darwin nor any careful biologist ever supposed that the pruning-hooks accounted for the tree or for its new shoots. Darwin began the scientific study of variations, in regard to which he said, with his usual frankness, that our ignorance is immense. We may say the same to-day, yet considerable progress has been made. To Weismann in particular we owe the clearing up of the idea, obscure to Darwin, that variations have *a germinal origin*. The newnesses may not find visible expression until embryonic life is over, or even until adult life begins, but the originative change is to be looked for in some permutation and combination within the complex germ-plasm of the egg-cells and sperm-cells—either in their making, or in their maturing, or in their union at fertilisation. If we compare the hereditary initiatives, technically called "factors," "genes," or "determinants," to the cards of a pack, many opportunities for shuffling are afforded by the intricate manœuvres of the nuclear rods or chromosomes in which the genes are located in each germ-cell. Very important, for instance, is the reduction-division or meiosis which occurs at the ripening or maturation of the egg-cell and of the sperm-cell, for in this peculiar mode of cell-division the number of chromosomes is reduced by a half, the normal number being restored when a "reduced" egg-cell and a "reduced" sperm-cell unite in fertilisation—which may be defined as the intimate and orderly union which is the beginning of each new individual organism, if reproduced in the ordinary way. In the halving of the number of the chromosomes in maturation, and in the restoring of the normal number in fertilisation, there are opportunities for novel permutations and combinations—in other words, for *the origin of the new*.

There is also a remarkable process of "crossing-over" between two adjacent chromosomes lying together inside the nucleus, for an area of the one passes over and changes places with an equal area in the other. As the genes, though invisible, are known to lie in linear order in each chromosome, the "crossing-over" affords yet another possibility of permutation and combination.

Then there is the pooling of the two "reduced" sets of chromosomes that occurs in the microscopic process of fertilisation, to which Weismann applied the term "amphimixis"—the mingling of the paternal and maternal inheritances—each complete in itself, though differing in details. Moreover, one must think of the amphimixis not as the mere mingling of two complex organic substances—half paternal and half maternal: it is the union of two living units or implicit organisms to form one—the fertilised egg-cell. The fertilisation nucleus, with an equal number of chromosomes from each parent, is a reorganised unity which initiates the development of a new individuality. The re-organisation promotes novelties and it also tends to nip the incompatible and the pathological in the bud. One reason why mules, such excellent animals in themselves, are rarely fertile is probably some incompatibility in the chromosomes of the

two parents—the horse and the ass. The first generation succeeds, but there are rarely any more. In the great majority of animals, the crossing of two distinct species is unsuccessful in yielding even one generation of hybrid offspring.

As knowledge grows, the fortuitous seems to shrivel. Variation occurs within limits, within limits narrower than those seen in a kaleidoscope. The new departures must be congruent with what has been already established, just as the novelties that an architect will sanction in adding to a building must be in keeping with the style of what has gone before. In many cases variations in plants or animals are quantitative—a little more of this, and a little less of that, a longer wing and a shorter tail; and Darwin placed great reliance on the selection and hereditary accumulation of those small quantitative variations that are advantageous to their possessors, or conversely on the persistent elimination of those variants in which the new departure is on the disadvantageous side. One must, of course, draw a firm distinction between a variation that is disadvantageous and one that is positively pathological. For in Wild Nature the outcrop of anything pathological or disintegrative seems to be a great rarity, and likely to be nipped in the bud if it occurs. There is very little hint of congenital or constitutional disease in Wild Nature.

Another glimpse of *the frequent definiteness of evolution* is to be found in those rock-records where there is a very perfect preservation of fossil forms. There is sometimes, as in fresh-water snails, or in nautiloids and ammonites, an extraordinary gradation of species—F very different from A, yet connected ever so gradually to A through the intermediate B, C, D, E species or sub-species. In other words, the stages in racial evolution look like the stages in individual development, all is so gradual. To some extent this apparent definiteness of variation—this orthogenesis, as it is called—may be due to the fact that divergent variants were eliminated, but it is strange that these hypothetical divergent variants should be so rarely represented as fossils in these orthogenetic series. In other, more zigzag, lineages the occurrence of divergent forms, off the main line, is often very convincingly documented in the rocks.

Yet another glimpse of the definiteness of variability is seen in those series of species, to which we already referred, which show an arithmetical orderliness in the number of chromosomes in their cells. Thus there are species of rose with 7, 14, 28 and 56 chromosomes; and this is but one example out of many. Thus there are often quantitative differences between related species that recall those between related chemical elements.

Another good reason for discarding the nightmare idea that chance variations furnish the raw materials of evolution may be suggested. A germinal variation, *i.e.*, some new departure in a germ-cell, might well take the form of a change of metabolism involving an extra-production of some ferment, or implying an extra growing power in, say, the ectoderm or outer-layer cells, or leading to increased storage of reserves, and so forth. This variation has opportunity for expression in the development of the offspring, but there it finds itself in certain physiological and morphological trammels. It is not anything that can find expression: there are only a few possibilities open. Just as there are only some half-dozen great types of architecture among crystals, so there is but a limited

number of ways in which multiplying embryonic cells can arrange themselves. What is even more important are the physiological limitations established in living creatures that have been going concerns for millions of years. Thus in an ordinary higher plant, where the antithesis between foliar nutrition (leafing) and floral reproduction (flowering) is so pronounced, variations are likely to find expression in an emphasis on the one or the other. Thus, as Patrick Geddes has well shown, there is in evolution an ever-recurrent dichotomy or forking of the ways between the more grassy and the more orchidaceous, between the more leafy and the more floral. Thus plants with almost invisible flowers but abundant foliage are to be contrasted with the sparsely leafed, but exuberantly floral, such as the extreme case of the parasitic Rafflesia where the vegetative system is almost unrepresented, and there is a colossal flower a yard across; but this contrast is not that of fortuitous variations gradually selected as adaptations to different life-conditions, but rather that between the extremes of two trends—foliar or floral—that are of general occurrence. Similarly many evolutionary trends in higher plants are concerned with a lengthening out or a shortening down of the floral axis—two obvious developmental possibilities. So the new is not the fortuitous, but a fresh expression of individuality within certain constitutional limits.

Among animals a continual physiological alternative seems to have been between speeding-up and slowing-down; *e.g.*, between avian and reptilian types, but this dichotomy or forking of the ways is plainly related to the fact that metabolism has these two aspects, downbreaking or katabolism and upbuilding or anabolism. Or again, a typical life-history shows in varied guise an ascending and a descending curve, like an old-fashioned bridge—an ascent from embryo to larva, from larva to adolescent, from adolescent to maturity and parentage, whence the downgrade to ageing and senescence. Germinal variations may find expression in a lengthening-out or a shortening-down of a particular arc on the life-curve. In this way different types of life-history in related organisms have arisen, and after this deeper rationale is appreciated, it is time to turn to their selected adaptiveness to particular conditions of life.

Variations are broadly distinguishable as (1) minute *fluctations* of a quantitative character, which may mean much, as Darwin thought, if long continued and accumulated, *e.g.*, a lengthening of the feathers of flight; and (2) brusque *mutations* of a qualitative character, which make a definite step, large or small, without gradated intermediate stages, *e.g.*, a white blackbird. Darwin was much interested in discontinuous variations or mutations (also called "saltatory," "brusque," "sports,") but thought that they would be averaged off in crossing. It is now known, however, that when mutations come, they usually come to stay; they take a strong hereditary grip; as will be explained later on, they illustrate Mendelian inheritance.

We must admit, however, that it is especially when we consider mutations, where something distinctively novel suddenly emerges, that we feel the inadequacy of our knowledge in regard to the origin of the new. Let us sum up the possibilities :—

(1) Novelties may arise in kaleidoscopic fashion by new permutations and combinations of the hereditary factors or genes, notably in

maturation, "crossing over," and fertilisation. To some extent this may be thought of as shuffling of the hereditary cards.

(2) Changes in the nutritive stream within the body may provoke changes in the nature of the genes—a factor to which Weismann was for a time inclined to attach much importance. There can be no doubt that some changes in diet effect some novelty in the offspring.

(3) Important changes in the body, induced by environmental and functional modifications of a penetrating nature, *e.g.*, change of climate, may evoke changes of some sort in the germ-cells, though it would seem that these are not (as far as known) such that the original parental modifications reappear hereditarily in the offspring. A modification may be defined as a structural change in the body directly induced in the individual life-time by some peculiarity in surroundings, food or habits.

(4) Deeply penetrating environmental changes, saturating through the body, may provoke changes in the genes, as may be illustrated by recent experiments which indicate that gamma-rays may serve as variational stimuli, provoking the genes to change. Thus change of climate may induce changes in a race.

(5) There may be, as Weismann suggested, some form of germinal struggle and selection among the hereditary initiatives or determinants; thus if a particular kind is in course of being weakened by some variational trend, this deterioration may be hastened by some subtle form of intra-cellular competition. This is called "germinal selection"; but few biologists seem to favour the hypothesis.

(6) Just as a slipper-animalcule (Paramecium) may in certain conditions exhibit a remarkable process of scrapping and re-organisation called "endomixis," so there may be in the germ-cells a re-arrangement of materials; and here there is also some suggestiveness in the sudden way in which some microbes change their character from virulence to innocence, or conversely. We must never lose sight of the commonplace, that the germ-cells are living unities—implicit organisms.

(7) Finally, in regard to this central problem of Biology, the origin of the distinctively new, it may be suggested that it is difficult to think of a germ-cell, of a higher animal at least, as being without its psychical aspect. Unless we think of "the mind" as entering in at a later stage in development, the germ-cell must have a dim primordium of the subjective, the promise and potency of mentality. If so, it is easier to credit the microscopic implicit organism, as rich in initiatives as a germ-cell is, with making experiments of some sort in self-expression; and that is what mutations are. Perhaps we exaggerate the difficulty of the problem because we are so slow to take the psycho-biological point of view. That mind may influence body in the highest expressions of both is a certainty of experience, though we cannot explain how it is done; perhaps the same holds in the apparently simplest cases of germ-cells on the one hand and unicellulars on the other, that the first stirrings of what will be individual and racial mind are not without influence.

As Regards Heredity

Heredity is no "force" or "principle" or "entity," but a flesh-and-blood (or genetic) relation between successive generations, such that like

necessarily tends to beget like. This depends on *the continuity of the germ-cells*, a fact brought into prominence by Weismann. What it means is that, that if a fertilised egg-cell be thought of as containing the initiatives or "factors" of a number of qualities, *a*, *b*, *c* . . . *x*, *y*, *z*, it divides into many cells in which these same qualities are continued, for ordinary cell-division, as we have already mentioned, is meticulously exact. But while the great majority of the cells of the developing body undergo division of labour, whose structural aspect is called differentiation, some expressing more of the qualities *a*, *b*, and others more of the qualities, *y*, *z*, and so on, there are other cells which do not share in body-making, but retain in unspecialised intactness the original qualities, or initiatives of qualities, *a*, *b*, *c* . . . *x*, *y*, *z*; and these cells become the foundations of the reproductive organs of the offspring. They form other cells like themselves, that is to say, more germ-cells, and some of these are in due time liberated to start another generation. As these germ-cells (the egg-cells and sperm-cells) have in intactness the qualities *a*, *b*, *c* . . . *x*, *y*, *z*, they will develop into similar organisms, provided always that the appropriate environment is forthcoming. Thus there is a continuance of a specific organisation from parents to offspring and so forth; and this continuance, not very happily termed transmission, is the central fact in heredity.

Yet we can only say that like *tends* to beget like, for heredity includes the possibility of variation, which is an incompleteness or change in the hereditary resemblance. The inheritance, the "natural inheritance" as Galton called it, includes all that the organism is or has to start with in virtue of its hereditary relation with its parents and ancestors; and this implies the inclusion of any novelty or variation which may have occurred, as we have explained, in the intricate history of the germ-cells. Any viable inborn novelty of germinal original is *ipso facto* transmissible or continuable; and no organic change that is not proved to be transmissible can have a direct part in evolution. Thus heredity is a condition of evolution.

This raises the much-discussed question whether individual modifications, badly called, "acquired characters," can be handed on as such, or in any representative degree, to succeeding generations. As we have already said, a modification is an individually acquired bodily change, directly due to some peculiarity in functioning, nutrition or environment, which so transcends the limits of organic elasticity that it persists after the inducing causes have ceased to operate. Exercise strengthens a muscle; sluggishness leads to a deposit of fat; deficient food brings about a degeneration; altered diet is followed by a change in the wall of the gull's stomach; total darkness leads to the gold-fish becoming quite blind; a man becomes tanned in the course of years of work in India; a sheep transported to a cold country thickens its fleece; a white Proteus from the Dalmation caves soon becomes dark-coloured in a well-lighted laboratory; and so on through a very long list.

But if we ask whether these modifications can be hereditarily continued or entailed on the next generation, even in a slight representative degree, the evidence for the affirmative is very far from convincing. Modifications are often of great importance for the individual organism that acquires them, but they do not seem to be handed on as such, and if so they cannot

be of direct importance in the evolution of the race. There are some puzzling cases which lead the cautious biologist to keep the question open, but on the whole it must be said that there is little convincing evidence to show that a bodily modification is ever continued in the inheritance. This should not lead to any depreciation of the importance of nurture, or of changed nurture, for the individual, since the same advantageous modifications can be hammered on afresh for each successive crop of organisms ; and disadvantageous modifications may be similarly evaded. It should also be noted, as Weismann always emphasised in his criticism of Lamarckian theory, that some deeply saturating influences, say of food and climate, may influence the entire organism, including its germ-cells, so that the germ-plasm may be affected, for better or for worse, *along with the body* ; and a germinal change thus induced would naturally find expression in the next generation. But this is very different from Lamarck's theory that modern giraffes have long necks because of the hereditary cumulation of the minute increases acquired by many generations of ancestors who stretched out their cervical vertebræ as they reached up to the leaves on higher branches. It is very different from Herbert Spencer's theory that he had small hands because his father and grandfather, being schoolmasters, were habituated to such neat manipulations as sharpening pencils ! Yet as it appears to many incredible that experience should not count at all as a factor in organic evolution, it must be noted that this depreciation of the importance of individual experience is not involved in a rejection of the evidence adduced in support of Lamarck's theory of *direct* adaptation through use and disuse. Experience has certainly counted, for it is in their daily experience and in expressions of their new desires and needs (Lamarck's *besoin*) that organisms test the novelties with which germinal variability has endowed them. It is in experience that new departures are tested, and the testing often determines whether they are continued to many offspring, or to few, or to none at all.

In viviparous organisms, such as seed-bearing plants and all mammals save two, there is a more or less prolonged partnership between the offspring and the parent. The seed is a young plant intimately bound to its parent, often for a long time before it is scattered. The unborn young mammal is bound to the wall of its mother's womb in a very intimate partnership, which might well be called symbiosis. In both these cases it is plain that the young creature may be profoundly influenced while it is still in organic continuity with its parent, and though this influence, both plus and minus, is not in the strict sense part of its inheritance, it may count for the individual offspring as if it were. Thus there may be a general strengthening or a general weakening of the young mammal's constitution according as the mother's health is vigorous or depressed. But this is certainly not what is meant by " the transmission of an acquired character."

Here, also, it may be noted, as before, that in mankind the extra-organismal inheritance, usefully called the *social* heritage, may have an influence on the offspring so powerful that it may be compared to that of the *natural inheritance*, whose bearer is the germ-plasm. In social animals, such as ants and bees, rooks and beavers, there is a dim adumbration of

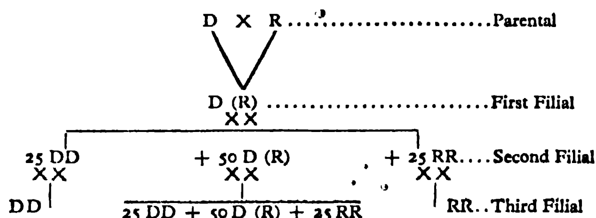
the social heritage which becomes so determinative in man, and is indeed one of the criteria of the sociological as different from the biological. More and more in modern times does the social heritage become the custodian of human progress; yet the inheritance of a healthy body is as fundamental as the heritage of truth, beauty and goodness is supreme.

The whole science of heredity has been changed by the discovery of "Mendelian Inheritance" by the Abbot Mendel in 1865, and by its re-discovery by De Vries, Correns and Tschermak in 1900. Every inheritance is largely made up of a series of "unit characters," which do not blend or break up, but remain intact from generation to generation. So far as is known these "unit characters" are represented in the germ-plasm by ultra-microscopic differentiations localised, in linear order, in the chromosomes of the nucleus of the egg-cell and sperm-cell; and, as we have already noted, they are called hereditary "factors," "genes," or "determinants." They are invisible, but they are not symbols; they are living initiatives of subsequent differentiations, leading to what are called the hereditary characters of the organism. But several genes may be concerned in determining one character, such as the colour of the hair; and one gene may influence the development of several characters, as some change in the chemical routine may readily do. A gene or a linkage of genes may germinally represent a large constitutional peculiarity, such as sex or rapidity of reaction or immunity to some disease; at the other extreme it may be the determinant of some triviality, such as some new grimace on a snapdragon flower or a new colour in a fruit-fly's eye.

These unit characters, whose origin has been well-studied, since they recur under observation and in experimental conditions, are known to arise as mutations, that is to say, as sharply-defined, brusque novelties which are not connected by intergrades with the condition found in the originative stock. They may be large or small, important or trivial; but they all behave in the same way in inheritance, they do not blend or break up, they "mendelise." As instances may be named: gigantism or dwarfism in peas, green or yellow seed colour in peas, the colour of the iris, short hair or Angora hair in rabbits, crests in poultry or none, horns in cattle or none, bands on a wood-snail's shell or none, night-blindness or normal sight in man, broodiness or its absence in hens, dentate or entire margin in nettle-leaves, and so on through scores of well-established cases. The drawback, indeed, to giving a list of instances is that we are thereby apt to obscure the fact that a very large number of hereditary features have been shown to be unit characters which mendelise.

As an example of Mendelian Inheritance, and that is all that can be attempted here, let us take the picturesque case of the Japanese waltzing or dancing mouse. This variety of the common mouse has some obscure peculiarity in its nervous system that behaves as a unit character. It has the habit of dancing round in circles, and with this other idiosyncrasies, such as deafness, are associated. Now if a waltzing mouse be paired with a normal mouse, all the offspring are normal; and this fact is expressed in the statement that normality is dominant and waltzing recessive. But if the apparently normal hybrid offspring, the first filial (F.1) generation, pair amongst themselves or with others like themselves of similar history, what is the character of the second filial (F.2) generation? Mendel found

that, on an average, 75 per cent. will show the dominant feature and 25 the recessive. In other words, in a dozen F.2 mice (of the history just given) there will be nine normals and three waltzers. If these waltzers are paired together, or with others of similar history, they will yield waltzers only—leading on to a future lineage of perfectly pure recessives, as long as no dominants are allowed to mingle with them. As to the 75 per cent. of dominants, a third of them are shown by breeding to be pure dominants comparable to the pure recessives, while two-thirds of them will be impure dominants like their immediate parents—apparently, but not really normal. If these are bred together they will yield the same proportion of three normals to one waltzer; and of the three normals one will be genetically wholly normal, while two will have the recessive or waltzing character unexpressed in development, but latent in some of the germ-cells, as further breeding shows. If we use the letters "D" and "R" for the dominant and recessive characters respectively, and allow them for shortness to stand for the possessors of the respective characters, then the Mendelian rule may be briefly expressed in schematic form :—



Here D (R) means that the recessive character, though not patent, is latent in the inheritance. The doubling of the letters (DD and RR) means extracted (or genetically pure) dominants or recessives. The inbreeding of similars is indicated by the two crosses (XX). Returning to the waltzing mouse, we see that all in the hybrid or first filial generation would appear quite normal, behaving as such. In the second filial generation a quarter of the total number of mice might be sold as pure waltzers, though neither of their parents could be so described. And a third of the dominants of the same second filial generation might be certified as pure normals, though in each case the grandparent on one side of the house was a waltzer.

It may be noted that it is sometimes possible to distinguish the pure from the impure dominant externally, as is well illustrated by blue Andalusian fowls. When black and white Andalusian fowls are paired the resulting chickens show a finely divided pattern of black-and-white marking, which is called "blue." Black is dominant, D; white is recessive, R; and blue, D (R), is the impure dominant. If the blues are paired together, the average outcome per dozen chickens will be three blacks (DD), three whites (RR), and six blues D (R).

When the parents differ not in two contrasted characters, but in two pairs or three pairs, the resulting types will be more numerous, but the striking feature throughout is that the various dominant and recessive characters appear in successive generations in definite proportions and in their entirety or intactness. This is due to a segregation of the genes or

factors in the germ-cells, for if there were 100 egg-cells, 50 of them would carry the dominant gene and 50 the recessive. The same is true of the sperm-cells, and fortuitous fertilisation of D or R egg-cells by D or R sperm-cells must yield the Mendelian ratio—1 DD + 2 D (R) + 1 RR, where only one pair of contrasted characters is concerned. Mendel had this idea of the segregation of the hereditary factors among the germ-cells of the hybrid D (R) generation, but he was naturally unaware of the fact, demonstrated by modern cytology, that the arrangement which secures this segregation is afforded by the reducing or meiotic division that occurs at the maturation of both egg-cells and sperm-cells, when the number of chromosomes in each unit is halved.

Before we leave this mere suggestion of one of the most important of modern biological discoveries, of equal theoretical and practical importance, we may notice, to avoid misunderstanding, that no one as yet understands why one of two contrasted characters should be dominant and the other recessive. The terms simply express the genetic fact that one of the two contrasted characters finds expression in the development of the offspring, while the other does not. There is no suggestion that the dominant character, which finds expression in the hybrid offspring (F.1), is stronger, older, more positive, or fitter than the recessive character, which remains latent or unexpressed. Another point is that Mendelian inheritance typically occurs when two contrasted true-breeding races or varieties or sub-species of *the same species* are paired. For the occurrence of fertile hybrids between related species is only occasional. It is typical of species that they are *not* fertile with related species, though not a few species-hybrids, *e.g.* mules, are well known.

Many biologists still recognise other modes of inheritance besides Mendelian, such as *blending*, as in " half-bred " sheep, the true-breeding result of crossing, say, Cheviots and Leicesters ; or *coarsely particulate*, as in a piebald pony ; or *reversionary*, as when a foal shows stripes on its withers ; or *complete hereditary resemblance* as in very pure-bred stocks where homogeneity prevails.[1]

Struggle and Selection

Darwin's conception of the struggle for existence was far ahead of that promulgated by many of his coadjutors, such as Huxley, and some of his disciples have strayed further than Huxley from the facts of Nature. For Darwin insisted that the phrase is to be used in " a wide and metaphorical sense," since the reality includes much more than life-and-death competition around the platter of subsistence. It includes efforts to baulk a callous environment and to secure for the family a good send-off in life ; it rises from cannibalism to an endeavour after well-being ; it extends to all the reactions that organisms make against environing difficulties and limitations.

Selection is a general term for all the sifting and winnowing that goes on in Nature, and few have realised its subtlety as Darwin did. It may be competition so keen that one variant with a plus novelty may kill another

[1] The subject of Mendelian Inheritance is also discussed in the Article on *Sex*, p. 261.

without it; or it may be between co-variants of the same species and a common enemy; or it may be entirely non-competitive, *e.g.* against an unfriendly environment. The selection may be *lethal*, when the issue is a quick or a slow killing off, the relatively fitter surviving; or it may be *reproductive*, when one type prevails in the course of time by having larger and more successful families than its rival or neighbour. What determines survival varies greatly from case to case. For the issue may depend on hardiness of constitution, on inconspicuousness, on swiftness of foot, on quickness of sense, on ability to utilise a long bill of fare, on capacity for winter-sleep, on nimble brains, on good digestion, on way-finding or homing, on fertility, on parental devotion, on beauty—and we need not continue the list. The important point is that the selection or sifting is in operation whenever and wherever the degree of survival and success depends upon the presence or absence of particular variations, which are possessed by some members of a species but not by others. A famine may reduce an animal population, say of lemmings, to a mere remnant, but it will not affect the character of the species unless the survivors survived in virtue of the possession of some particular qualities which were not shared by those eliminated, or not shared in the same degree. It is only *discriminate elimination* that counts.

In the sifting that goes on in Nature the agent is the struggle for existence, and the sieve is the system of inter-relations—the web of life—in which the organisms in question are involved. Thus the sifting may be so penetrating that it eliminates and fosters in reference to characters which might be at first sight regarded as trivial. We might say that natural selection can separate those organisms which say Shibboleth from those that say Sibboleth.

Besides the many forms of natural selection, there is sex selection, where the sifting is in relation to reproductive success or preferential mating, and there are other forms, all operating in the same general way; the survivors surviving, the successful succeeding, because they differ in some particular feature from those that are eliminated. And there may even be survival value in *not* varying, as very conservative types, like the Lamp-Shell Lingula, the King-Crab and the Pearly Nautilus, well illustrate.

In domestication and cultivation man practises what Darwin called "Artificial Selection"; he works deliberately towards a desired end. But this cannot be said of natural selection, which goes on automatically. Yet it must be carefully noted that natural selection operates in reference to the already established *Systema Naturæ* and web of inter-relations, so that is far removed from fortuitousness. Moreover, various evolutionist thinkers, notably Professor James Ward, have pointed out—it is a very open secret—that living creatures often take a share in their own evolution by striving to make the most of their hereditary equipment in the given circumstances, or even by bending these circumstances to their will. This is part of the truth in Lamarckism, that the more vigorous animals always show something of the bent bow of endeavour. Organisms play their hand of hereditary cards for better or for worse, and thus, though they have neither ideals nor conceived purposes, they take a share in directing their own evolution. The picture of Organic Evolution as "a chapter of accidents" is an unwholesome caricature.

Isolation

As regards isolation, it is illustrated whenever there is a narrowing of the range of inter-crossing among the members of a species. It may be by a peninsula becoming an island or an archipelago, by a flood changing a river-bed, by a lava flow interposing a barrier, or by the development of an impassable stretch of desert-land. Or apart from such geographical isolations, there may be reproductive variations which establish among the members of a species differences in the time of sex-maturity, so that only similar forms can pair together. Or the same may result from variations in size and structure. Or there may be psychical preferences and antipathies which serve to narrow the range of inter-crossing. On the whole, inbreeding or endogamy tends to stabilise the characters of a species, while outbreeding or exogamy tends to promote an outcrop of new variations, two facts familiar to breeders, and often illustrated in human history. Close endogamy does not seem in itself to induce degeneracy, unless there are marked hereditary taints and defects in the inbreeding stock. In many cases a recessive Mendelian character of a minus kind, which is masked when there has been crossing of dominant-bearing and recessive-bearing individuals, is exposed by inbreeding, when two recessive-bearing individuals are more likely to pair. The outcrop of the deteriorative recessive characters is often referred to the evil influence of consanguineous unions as such, whereas it is really due to the conditions of Mendelian inheritance.

On many islands there are unique species, such as the St. Kilda Wren, the St. Kilda Mouse, the Fair Isle Mouse, and the Orkney Vole ; and one of the facts that most impressed Darwin on his famous Columbus voyage on the *Beagle*—discovering a new world, evolved and evolving—was seeing seven or so separate species of Giant Tortoise on as many islands of the Galapagos Archipelago. There can be little doubt that these separate species represent divergent offshoots from an original species which inhabited a great equatorial peninsula projecting from Central America into the Pacific. When a partial submergence of the peninsula resulted in an archipelago, variations emerged in the groups of tortoise on the various islands, and the fact of isolation assisted in the process of species-making. This view is corroborated by the fact that the Giant Tortoises do not voluntarily swim, and thus have a restricted breeding-range. This illustrates the isolation-factor in Organic Evolution.

In Conclusion

Three general considerations must be briefly alluded to in conclusion :—

(*a*) In spite of ourselves we tend to speak too often of past evolution, and too little of that which is at present going on. This is not unnatural, since the period under man's observation and record is so short compared with the hundreds of millions of years during which Organic Evolution has been in progress. Moreover, some types have long ago reached positions of well-established equilibrium, and do not seem to have varied much for ages, or to be varying in any marked way to-day. On the other

hand, we have before our eyes the continued changefulness of domesticated animals—there is always some new dog on the market—and of the cultivated plants, as is evident in flower-shows, and in such exuberantly mutant forms as Lamarck's evening primrose, *Œnothera Lamarckiana*, which has been prolific in novelties. Outside man's shield, though under his scrutiny, there are some well-known mutating species like the fruit-fly, *Drosophila ampelophila*, which has in the twentieth century given rise to numerous true-breeding varieties. If these occurred in Wild Nature they would be regarded as new species. They are possible species in the making. It is not very long since some long-tailed field mice (*Apodemus* or *Mus sylvaticus*) were accidentally marooned on Fair Isle, one of the Shetlands, and there establishing themselves, gave rise in the course of generations to a new species, *Apodemus fridariensis*. Within recent years, the story has repeated itself, for some Fair Isle mice were taken by chance to the Ultima Thule of Tacitus, the island of Foula, some twenty miles out into the Atlantic, and have there by further variation given rise to a new variety, *Apodemus fridariensis thuleo*, which may, by continued divergence and stabilising, become clearly worthy of a new specific name. For approximately stable varieties are new species in the making. It is a question of degree. The important fact is that *evolution is going on*.

(*b*) In the minds of some loose thinkers, especially of anti-evolutionist prejudice, there lingers an erroneous view of the origin of species which is often expressed in the criticism that no naturalist has ever seen one species of plant or animal turn into another. It might be replied that brusque mutants occur which are at a leap as different from their parents as are many instances of related species ; or it might be pointed out that the mills of organic evolution grind very slowly ; but the final answer is that the critics are looking for a phenomenon which the evolutionist has not even imagined. What has happened, and still happens, in the origin of a new species is that a number of similar variants diverge from the parent stock, breed together, attain specific stability, and find a footing in the struggle for existence, often in some slightly novel niche of opportunity. If their novel features are very markedly advantageous as compared with those of the originative stock, the new may oust the old ; or as often happens, the old and the new may get along together, probably with some slight difference in habits and habitat. But one species does not turn into another ; that would be magic, not evolution !

(*c*) The origin of well-marked newnesses is the most striking feature in evolution and the crowning wonder of life. We refer especially to great steps, such as the origin of birds from an extinct reptilian stock, or the origin of warmbloodedness or viviparity, or the origin of tentative men. In these new departures and in many others more or less comparable in magnitude, the step is in kind rather than in degree. We cannot but feel that what appears is too big for its premises ; it is certainly more than the additive result of its antecedents. This is expressed by calling it a new synthesis, a new " whole," an " emergence." The terms do not explain anything, but they lay useful emphasis on the fact that many of the great novelties that have successively arisen in the course of the ascent of life are disclosures of some new aspect of reality which could hardly have been

anticipated. Even below the level of the living there are some good illustrations of emergence, and one of the best is water. From a union of two gases—hydrogen and oxygen—there emerges liquid water, an unpredictable novelty with remarkable properties of far-reaching importance, making the whole world new. At the other end of the scale, the appearance of man, though implying a slow dawn, was an emergence, for man's reason is a power very different from intelligence, which he shares with the higher animals, and man's language is very different from animal speech. The story of Organic Evolution shows a succession of creative emergences.

The " man in the street " has often a philosophy—an attempt to think of all things together, and this colours his life. In the philosophic or synoptic picture a large place must be found for Organic Evolution ; and it is therefore very important that everyone should have a clear vision of the actual facts, which are often travestied in careless exposition. Even the expert philosophers are sometimes open to the reproach of dealing with worn clichés of Nature, instead of with the facts themselves. Thus it is seldom recognised that the evolution of Animate Nature shows trends towards human ideals. In Wild Nature there is almost no disease ; Organic Evolution makes for health. Animate Nature also favours that mastery of natural energies—a food store as its simplest—which allows of a certain freedom of action and victory over vicissitudes. Organic Evolution makes for wealth. But if health and wealth be regarded as no more than pre-conditions of man's true progress, which is a balanced all-round movement towards a fuller realisation of the true, the beautiful and the good, the biologist can advance his position and maintain that there are in Organic Evolution great trends towards even the highest values. Thus Beauty is almost omnipresent ; the success of Birds and Mammals is a testimony to the survival values of the raw materials of morals ; the largest fact in Organic Evolution is the growing emancipation of Mind, and many are the rewards that have gone to clear-minded as well as able-bodied animals. Part of the momentum of Organic Evolution works in Man to-day, and while we always hope that the ape and tiger may die within us, we are not perhaps sufficiently appreciative of other pre-human legacies which are in line with our best endeavours.

Finally, it is often and rightly said, as we have just been suggesting, that Man must be considered in the light of Organic Evolution, the outcome of an age-long process—and also a promise. But we must also envisage Organic Evolution in the light of man, since it is in Man that Nature finds its chief significance. We might say, *Finis coronat opus* ; were we not reluctant to think of any full stop to the evolutionary process as a whole.

SEX

THE NATURE OF SEX

Sex, in its manifold manifestations, is so intimately woven into the fabric of human life that anyone, be he scientist or layman, must approach its study with awakened interest. When once the mind becomes entangled with the problems, personal and social, which cluster around sex, then, inevitably, insistent wonder and curiosity are aroused to yield in their turn, all too commonly, it would seem, myth and legend, taboo and doctrine. In every generation and in every land the complex of sex has been, and still is, regarded as one of the outstanding problems of the day. With passing time the problem has remained unchanged, but the attitude of peoples toward it has varied. In some societies an interest in matters pertaining to sex has been openly admitted; in others it has been anxiously and imperfectly concealed. To-day and in most countries it is no longer accepted that sex is one of the great mysteries that defy understanding, and the recognition of the fact that its peculiar mechanisms are complicated merely stimulates enquiry and no longer inhibits effortful analysis. The point of view is gaining ground that sex is a matter to be examined and explained.

Science, which has enabled man to know the laws which govern the movements of molecules and the mechanisms which drive the world on toward its destiny, has also taught him that he may think of himself, with all his lusts and pains, his doings and his dreams, his beginning and his ending, as the expressions of physico-chemical forces; even though, beyond and above all these, something other and additional may exist. It is this attitude of mind which has encouraged man to tear aside the veils which have concealed the problem of sex, and thus to learn that in all probability all expressions of sex are nothing more or less than the results of the workings of a knowable, analysable, chemical mechanism. We know that male can be transformed into female : female into male ; that those details of structure which distinguish the sexes can be destroyed and as easily restored. We know a great deal of the manner in which, and of the time at which, sex is determined in the life history of the individual, and that the mechanisms involved in this process can be manipulated to an extent far beyond the imagination of those who are unacquainted with recent developments in this field. That we know these things and more is due to the fact that sex—an attribute of the living organism—has become a proper study for the biologist who, unlike the layman, does not regard sex as an exclusively human affair. To him, sex in man is only one instance of a phenomenon which is to be encountered in countless other forms of life. That we know already a little about ourselves is due to the fact that we have learned a lot about other forms. The reader who prefers to hold the view that man is surprisingly different from mouse or microbe in respect of the fundamental phenomena of life must not expect to

glean much from the writings of a biologist. The comparative method is universally employed in scientific enquiry, and biology has ever assumed that such phenomena as natality, mortality, sexuality and reproduction, for example, are not the peculiar possessions of any one particular species, but are the attributes of living things in general.

To the layman, unacquainted with the more recently disclosed facts, nothing could appear simpler than to define sex by stating that there are two sexes—male and female; that male differs from female in that he provides one kind of germ-cell, the spermatozoon (Gk. *sperma*=seed, *zoon*=animal), she another kind, the ovum or egg, and that, associated with this main difference, there are others which permit the observer to tell at a glance whether any given individual belongs to one sex or to the other. It is the case that one can classify the individuals of those forms of life with which the layman is acquainted as males and females, but when one undertakes a survey of the multitude of different forms of animal and plant life one finds that the distinguishing features quickly disappear. Yet, though in many forms the sexes can no longer be distinguished, it can be shown that amongst these there is still sex. What, then, is sex? The layman may perhaps find an answer, but no biologist has yet given a sufficiently comprehensive and satisfactory reply. We do not know what sex is. Biology has not yet reached that stage of its development when it can describe the objects of its searchings. To one who is acquainted with the history of the sciences this is not surprising, for it will be found that the nature of the subject of scientific enquiry is commonly the last thing to be discovered. The physicist writes easily of matter, but he is not able to state what matter is. The biologist speaks easily about sex, yet he does not know what sex is. For the present, he disregards this fact and busies himself legitimately with a description and a consideration of the varied expressions of certain phenomena which are regarded by him as pertaining to the sex-equipment of the individual.

One need not travel far in order to prove to oneself that superficial structural differences in characterisation are not satisfactory criteria for identifying the sex of an individual. The cock can be distinguished easily from the hen of a domestic fowl; to distinguish the drake from the duck of many of the self-coloured domesticated breeds is not so simple; whilst to distinguish the gander from the goose requires the knowledge of an expert breeder. And if one passes from the bird to the fish and onwards in a survey of the simpler forms of life, one at once finds that in countless forms in which sex exists there is no ready means of distinguishing male from female. So that, whatever sex may be, it does not demand the existence of two types of individuals, readily distinguishable one from the other by differences in their superficial characterisations.

In many of the forms in which male is not to be distinguished from female by differences in form or adornment, the sex of the individual can be recognised by reference to the rôle that the individual plays in the act of sexual congress. In man and in domesticated animals generally the male, during the sexual act, deposits the spermatozoa elaborated in his testes within the genital tract of the female. But reference to other forms shows that mating does not necessarily demand the intimate congress of two bodies. In the case of certain newts, the male deposits a gelatinous

capsule containing his spermatozoa on the bottom of the river or of the aquarium, and the female then takes this up within her vaginal orifice. There is a small cuttlefish in which the semen of the male is passed into a transformed arm, which then breaks away and makes its way through the water until it meets a female of the species, into whose body it passes. In all these cases, mating involves the transference of spermatozoa elaborated by special organs—the testes—within the body of the male to the genital tract of the female. But, in other forms, mating is concerned with the transference of material which cannot be regarded as being either a part of the sex equipment of the individual or a product thereof. The slipper animalculæ, Paramæcium, for example, which is a minute, single-celled organism that lives in stagnant fresh-water pools, mates by forming a temporary union with another individual, quite indistinguishable from itself, by means of a bridge of living matter or protoplasm (Gk. *protos*=first; *plasma*=form). Across this bridge nuclear material is exchanged, and thereafter the individuals separate again. In other forms, mating consists in the complete and permanent fusion of two complete individuals to form one.

It is difficult to trace a common feature through all these instances of mating. In the lowest forms it involves the permanent union of two whole individuals. Next comes the transient union of whole bodies and the interchange of bodily material. Thereafter comes the relegation of the task of providing the sexual contribution to special organs of the body. Associated with this are refinements in the mechanisms, by means of which the spermatozoa are transferred into the genital passage of the female. These make fertilisation of the ova by the spermatozoa more certain. This being so, the opportunity for practising economy in the production of ova is provided. Many fish, for example, extrude millions of ova during the breeding season, but, since fertilisation occurs in the water when ova chance to meet the spermatozoa extruded by the male, the majority are never fertilised. In the mammal, on the other hand, the spermatozoa are deposited in the genital tract of the female, and fertilisation is practically certain. It is a matter of interest to note that such economy is practised only by the female. The male, during the act of sexual congress, provides enough spermatozoa to fertilise millions of ova, yet commonly only one ovum is available for fertilisation. The variety in the matter of mating amongst the different species is such as to make it impossible to derive any general principle from a comparative study. The sex of an individual cannot be identified by reference to the rôle played by that individual during sexual congress.

It would seem that one is almost driven to the view, that the nature and meaning of sex can only be recognised by bringing it into a definite and essential relation with reproduction. Society and the needs which have had their origin in the peculiarities of its structure have indeed always demanded that sex and reproduction shall not only be related one to the other in their actual expression, but also that sex can only be understood and justified by postulating that it is the mechanism which Nature has ever used for the preservation of the species and for the improvement of the race. It will be found that in most biological text-books, " reproduction " is the title of the chapter which includes a subordinated account

of sex. Morals, as determined by recent forms of civilisation and as taught by cleric and philosopher, unhesitatingly state that sex is the servant of reproduction; the means whereby Nature achieves the continuity of the species; the reward which Nature pays to the individual for fulfilling its duty in begetting its kind. Schopenhauer, the great German philosopher, who was the first to express clearly the argument that love and sex are nothing but mechanisms which Nature created for the purposes of serving reproduction, held the view that the attraction which two individuals feel for each other is to be explained only by reference to a purpose, and could best be understood as the working of a mechanism devised by Nature for the drawing together of those individuals suitably matched for reproduction. Such views as this impressed and even guided biological thought for generations. It is to be noted that they are not contributions of the science itself, but impositions born of sociological necessity or of theological preference. They have had a definitely degrading influence upon the logical structure of biology, and far too few biologists have rebelled against this interference of social and theological demands in the development of their own particular science.

It is too commonly forgotten, that the scientist of to-day does not concern himself with the meaning and the purpose of things. Until he leaves science for philosophy, he is not interested in the great generalisations which gripped the minds of men in older days, and which began with "why" and asked for final solutions. He does not seek ultimate truth, but only an understanding of the mechanisms which underlie the phenomena of life and the attributes of living and non-living things. He has not so much interest in the purposes of creation as in the methods by which they may have been achieved.

It can be understood how Schopenhauer's authoritative teaching would be welcomed by such as sought an endorsement of the common demand, that in any society wherein population increase is to be desired for any reason, everything that encourages a high birth-rate is praiseworthy and should be rewarded, whilst anything that tends to reduce the birth-rate is blameworthy and should be punished. Under such conditions sexual intercourse without pregnancy as a sequel must be avoided, and in order to discourage unfruitful intercourse the people must be taught that such is unpatriotic, even sinful. Furthermore, it would seem that in every society there have been and are sufficient biologists of position, who will provide endorsement for such attitudes by an appeal to what they regard as legitimate interpretation of scientific fact. In the past the biologist has justified feudalism, Manchester Liberalism, socialism, and every other type of social organisation and political programme by reference to selected biological phenomena, and they who have shown that it is not only right, but even natural, that the strong should devour the weak, can have no difficulty in accepting from the non-biologist the view that sex is but the servant of reproduction.

Without doubt, the chief reason for the prevalence of this point of view is the might of the impact of Jewish theology upon the sex-ethic of other peoples. It is of interest, however, to note that there have been peoples, such as the aborigines of Australia and the inhabitants of the South Sea Islands, who have been entirely unaware of the connection between sexual

intercourse and reproduction. To these fertility was the gift of a spirit, and mating, which was bound up in many rites and customs, had nothing whatsoever to do with parentage.[1] To other peoples, the Greeks, for example, sex has been justified simply and completely by sexual desire, and has been explained by reference to its nature and not to its apparent purpose. It is seen, then, that the point of view exhibited by many societies has not been universally accepted; and, in any case, it can be argued that the reasons which have persuaded such societies to the view that sexuality can only be justified by reference to reproduction are not themselves scientific. Of course this does not prove that the attitude itself is necessarily unsound. But when the matter is considered dispassionately, it will be found that it is impossible to endorse it by an honest appeal to scientific fact. It is true that sexual activity commonly precedes, leads up to, and passes on to reproductive activity, but the relationship of sexuality and reproduction is such that one can as readily argue that the purpose of reproduction is the replacement of sexual individuals as to argue that the purpose of sexuality is to make reproduction possible. If the sexual act leads to reproduction, then reproduction itself yields nothing but another sexual individual. Reproduction leads to sexuality just as much as sexuality ends in reproduction. Birth leads to birth, and so there is a continuous cycle with no beginning and no end, neither purpose nor cause.

This statement, however, is but a formal and logical one, and is not enough. It merely argues that the explanation of sex as a means of reproduction is not valid. It does not obviate the necessity of analysing the obvious interrelationship of sexuality and reproduction which undoubtedly exists. Even the slightest acquaintance with this subject shows that the relationship is so intricate and intimate, that it may well be doubted that any attempt at the analysis of this complex can be successful. Nevertheless, the point of view that such an analysis is both desirable and possible must prevail. It is true that the time has not yet arrived when a final answer to the question as to what sex actually is can be given; the present is but the period of preliminary analysis in the science of sex biology. For the time being, we must concern ourselves with a description of the object of this science and with a survey of its particular field, and it is to be recognised that, as knowledge increases, complications will arise which will demand revision of most, if not all, of the conclusions at which we may now arrive. In the development of any science, advance, in the first stages rapid, becomes retarded as the probings become deeper.

It is desirable to examine the question of the possible separation of sex and reproduction for the reason that unless they can be so separated neither can be analysed alone, with the result that much concerning them, separate and in association, cannot be understood. That they *can* be separated can be shown by an appeal to the comparative method of study. If we were to confine our attention to one species, then the task would be impossible, but if we compare sexuality and reproduction in the different species, and if we assume that all these possess certain attributes in common, our task becomes quite hopeful.

[1] For an elaboration of this point, see the Article on *The Beginnings of Morals and Culture*, p. 413.

A review of sexuality in its various aspects, and as exhibited by the many diverse living forms, reveals the fact that it is indeed usually associated in the most intimate fashion with reproduction. This is especially so if one's survey is restricted to the higher animals. But if it is extended so as to include invertebrate animals, plants and the unicellular organisms, one finds, amongst these, innumerable instances of reproduction without sex; in other words, that asexual reproduction—the production of offspring without mating—is as widespread as is reproduction with mating. Manifestly, therefore, sexuality is not essential for reproduction. The Indian stick insect, Dixippus, exists both in the male and female form, but the male is exceedingly rare and the mating of male and female has never been observed. The female lays a great number of eggs which develop without having been fertilised, and in this insect the male is to be regarded as a reminiscence of older times in the history of the species, when both sexes played their rôle in mating and when fertilisation was the rule.

It has long been known that the eggs of the sea urchin, which normally begin their development only after having been fertilised by the spermatozoa of the male, can be made to develop by being placed in sea-water, the salt concentration of which is higher than normal. Furthermore, it has been demonstrated that if the egg of the frog is punctured by means of a fine needle, it will develop into a tadpole and thence into a frog, though usually, before there can be reproduction, the ova of the female must be fertilised by the spermatozoa of the male. A " fatherless " frog has been produced, but as yet no fatherless mammal has appeared under conditions of controlled experiment. That this is so is not surprising, for there are so very many difficulties in the way; the egg of the mammal is so tiny and is so jealously guarded within the body of the mother. Examination of large numbers of ovaries of rats, however, has shown that in all probability unfertilised eggs begin to develop into embryos, and although this development does not proceed very far, nevertheless such instances clearly demonstrate that, in principle, the origin of a new individual in the rat can occur in the absence of any influence contributed normally by the sperm of the male. Since this is so, it follows that the production of offspring by the mammal, though usually intimately associated with sexuality, is not necessarily dependent upon it.

The architectural unit of the body is the cell. This is a minute mass of living stuff—the so-called protoplasm, enclosed (in most cases) within a capsule or wall. There are two kinds of living things—the unicellular organisms, whose bodies consist of a single cell, and the multicellular, whose bodies consist of many cells. In the latter, different groups of cells are concerned with different functions. One group constitutes the reproductive organs which elaborate the sex cells. If one examines a typical cell one finds that the protoplasm within is not homogeneous, but that by appropriate methods of staining this by means of dyestuffs it is possible to distinguish a central area—the so-called nucleus—which can be shown to differ chemically, and structurally, from the rest.

If one turns to the unicellular or noncellular forms of life, the Protista (Gk. *protistos*=first of all), the primitive organisms from which animals and plants arose, one can readily find evidence which seems to

show that amongst these sexuality and reproduction are not only distinct but are contrasted. They reproduce or multiply by a process of simple division : one individual dividing to become two. On the other hand, two individuals may fuse—conjugate—(and it is customary to regard this conjugation as a sexual process) and the result of this fusion is that the number of individuals is reduced and not increased. So also it is in the case of the human subject ; the origin of a new individual occurs in the union of two sex-cells to become one—the ovum and the spermatozoa, the gametes or marrying cells (Gk. *gametes* = spouse) fusing to form the zygote or fertilised egg, which by its continued division gives rise to the new individual. The process of building the new individual out of the fertilised egg is asexual, being nothing more than the continued division of cells, all having their origin in a single cell. It would seem, indeed, that the part that sexuality plays is merely that of providing the stimulus to this cell division. Normally this stimulus takes the form of the fertilisation of the ovum by the sperm, but as has been shown, this fertilisation can efficiently be replaced by relatively simple physico-chemical techniques.

There is no difficulty in showing, therefore, by an appeal to the facts of biology, that sexuality is not the only means of reproduction. Reproduction can occur without sexuality. It follows that one cannot argue that sex is, in all cases, the servant of reproduction. Still, one might argue that sexuality is necessary for reproduction in those forms in which it has been developed and in which sexual activity normally precedes reproductive activity. It has been urged that the fact that sexual reproduction is so common amongst the higher forms is an indication that it must be positively advantageous to its exhibitors. It is assumed that the higher forms possess greater efficiency in their functioning than do the lower.

But surely we have the right to ask those who compare one mechanism with another to define and to exhibit their standards ! By what yardstick are the modes of reproduction to be measured ? It used to be taught that sexual reproduction was more advantageous than asexual, for the reason that the union of cells derived from different bodies leads to rejuvenation. It is the case that the germ cells of the higher plants and animals perish unless they unite in fertilisation ; but it does not follow that senescence and natural death are fundamental phenomena inherent in all living tissues, or that conjugation (*i.e.* the temporary or permanent fusion of two individuals) and fertilisation (*i.e.* the fusion of two dissimilar sex-cells, sperm and ovum) are the only means of outwitting them. It is known that in many animals parthenogenesis (the process whereby an egg develops without activation by a sperm) can replace fertilisation as a method of reproduction, either temporarily or else permanently. Moreover, experiments involving the growth of cells outside the body on appropriate media, and of tumour cells transplanted from individual to individual, have shown that these can thrive indefinitely. It is abundantly established beyond all doubt that the living cell can multiply and flourish in the absence of any sexual reinforcement. Many are the cultivated plants which have been propagated continuously by root cuttings or grafts for long periods of time, and yet show no signs of diminished vigour. In fact, there are certain plant species which are completely sterile and which reproduce

exclusively by parthenogenesis (Gk. *parthenos*=virgin; *genesis*=descent) or by some other asexual process.

The conclusion that conjugation or fertilisation, with the resulting mixture of living contributions from two sources, implies rejuvenation was reached from the study of conjugation in noncellular organisms. The slipper animalculæ, Paramæcium, multiplies, as has been stated, by division of the individual into two. As soon as these daughter individuals have reached full size they divide again. Normally, however, there occurs, after a series of such divisions, a phase when this multiplication is replaced by conjugation. It was observed that as the age of a culture of Paramæcium increased, the frequency with which multiplication occurred became steadily reduced; and that after the period of conjugation the division rate again reached its full height. It was assumed, therefore, that continued asexual reproduction, as represented by division, could not go on without end, since the periods of such multiplication were followed by periods of physiological depression and then by the death of the culture unless conjugation occurred. Conjugation, it was concluded, removed the results of this progressive diminution in vigour. However, it has more recently been shown beyond all doubt that such degeneration of the stock can be due simply to faulty husbandry, and that the conclusion that conjugation was responsible for the rejuvenation of the culture is no longer tenable.

Other somewhat similar theories, formerly very prominent in biological teaching and all concerned with the nature and meaning of sex, have passed into obscurity. One of the most prominent of these was that concerning amphimixis (Gk. *amphi*=both; *mixis*=mingling)—the mingling of maternal and paternal contributions to the offspring in the fusion of two dissimilar individuals or gametes. This theory had its origin in the experience of breeders who had noted that crosses between different races, varieties and species, were often remarkable for their vigour, this commonly taking the form of a greater size, more luxuriant growth, earlier attainment of maturity, or greater resistance to unfavourable external conditions. The results of the early hybridisers gave rise to a widespread belief, that this crossing was itself the cause of this increased vigour, and that inbreeding—the mating of near relatives—was in the same sense the cause of degeneracy. It is now known that outcrossing, which involves the mating of two dissimilar types, does not invariably yield hybrid vigour, and also that inbreeding is not always harmful but that, in fact, it can be definitely advantageous, leading to the establishment of a uniform and true-breeding stock. For an understanding of the modern interpretation of the facts concerning these estimates of breeding, a certain acquaintance with Mendelian theory is demanded.

If the nucleus of a typical cell is examined it is found to consist of masses of material which take up stain eagerly and deeply and which is known as chromatin. In certain stages of the process whereby a cell divides to become two, this chromatin becomes aggregated in the form of rods —the so-called chromosomes. Modern Mendelism postulates that corresponding to all of the hereditary characters (details of form and of function) which an individual may exhibit, there are hereditary factors resident in the chromosomes. Hereditary characters can be classed in pairs

and the members of each pair are alternative. For example, the colour of the eye in man may be brown or else it may be blue. In respect of each character exhibited by the individual there are, in the cells of the body and in the unripe germ cells, spermatozoa or ova, two hereditary factors, one of which was derived from the paternal parent, the other from the maternal. Thus a particular individual may have received the factor for brown eye colour from both parents and thus be duplex for this factor, and homozygous (Gk. *homos*=same; *zygon*=yoke) for the character responding to them. An individual, on the other hand, may have received the factor for blue eyes from each of its parents, and therefore be simplex for the factor and homozygous for the character blue eye colour. But an individual which has received the factor for brown eye colour from one parent and the factor for blue eye colour from the other will be brown-eyed and it will be heterozygous (Gk. *heteros*=other; *zygon*=yoke), or hybrid, for the character it exhibits. In order to express this fact that when the factors for brown and blue are both present, the brown character prevails, brown is said to be dominant to blue and blue recessive to brown.

The individual carries the hereditary factors in pairs, and in the case of each pair the members may be alike or unlike. But, into the ripe gamete there passes only one member of each pair of factors. Thus, in respect of all the factors for which the individual is duplex, the gametes will all be alike, but in respect of those factors for which the individual is simplex, there will be two kinds of gametes, those with this factor and those without it. Thus it is that the individual "breeds true" for those characters for which it is homozygous.

It is assumed that inbreeding has but one demonstrable effect: it increases the degree of homozygosity, that is, the state of being homozygous for the characters exhibited by the stock, and duplex in respect of the factors corresponding to these. An individual is to be regarded as a combination of many thousands of hereditary characters, and probably in respect of most of them it is heterozygous. Inbreeding reduces this hybridity, and slowly but surely leads to a state in which the individual is homozygous for all the characters it exhibits. But all characters are not advantageous. In every one there are the hereditary factors which correspond to characters that maim and deform and kill. But since these are for the most part recessive in nature, the alternative normality being dominant in relation to them, they are hidden and do not work their will in the case of individuals which are heterozygous in respect of the characters corresponding to them. Only when an individual which is homozygous for such a character appears is the effect seen. Inbreeding provides the opportunity for such an individual to appear. Outcrossing reduces the chances of such an individual appearing, since it is unlikely that two comparatively unrelated individuals will be carrying, hidden in their hereditary constitutions, the factor for the same deleterious character. But just as inbreeding permits the appearance of undesirable characters, so does it also lead to the production of individuals which are homozygous for the useful, advantageous characters, and since the great merit of homozygosity is that its possessor breeds true, therefore, through inbreeding, there can arise a stock purged of its undesirable recessives and,

in virtue of its hereditary constitution, inevitably begetting offspring as homozygous and therefore as excellent as itself. Outcrossing, on the other hand, increases the heterozygosity of a stock. The good characters of one parent can reinforce the good of the other. The harmful recessives of one can be covered by the alternative advantageous dominants of the other. But hybrid vigour only follows when the contributions of the two parent are complementary and compensatory; profound disharmony can ensue when undesirable reinforces undesirable. It is because two comparatively unrelated individuals are less likely to carry the hereditary factors for the same deleterious recessive characters than are two comparatively closely related individuals, that sexual reproduction, associated with marriage laws that prevent the mating of close relatives, can perhaps be preferred to asexual methods of begetting offspring. But the advantages of sexual reproduction are not inherent in this particular system. The effects are referable to the peculiarities of the hereditary constitutions of the individuals that mate.

It has been argued that this amphimixis has played a most important rôle in evolution. New hereditary characters, advantageous or harmful, have their origin in an alteration in the hereditary constitution, that is, in the hereditary factors of the individual. Such an alteration is known as a mutation. In sexual reproduction such a mutation can have occurred in either of the two parents, and so mutations occurring independently in time and space can meet. This is not so, of course, in cases of asexual reproduction, for here there can be no pooling of advantageous mutations that have been endured by two individuals. A further advantage of sexual reproduction is that, by the pooling of the characters of two parents, offspring combining the advantages of both can be produced.

It is a matter of observation, however, that the majority of mutations would seem to be disadvantageous. In the case of asexually reproducing forms, such mutations would either eliminate or seriously embarrass their exhibitors. In sexually reproducing forms, on the other hand, such recessives could remain hidden for long periods and only be brought to light amongst the offspring of two individuals, each of which is heterozygous in respect of these characters. Thus a stock in which sexual reproduction is the rule could become slowly but surely loaded with harmful recessives, which almost certainly must lead ultimately to the appearance of degeneracy. Under such circumstances racial decay is inevitable. In contrast with this, the elimination of the unfit, in the case of the asexually reproducing forms, is swift and ruthless. Moreover, homozygosity in respect of advantageous characters can only be obtained if sexual reproduction is the rule and, in the absence of definitely controlled mating, after a very considerable time. In the case of the asexually reproducing forms, the state of homozygosity is attained relatively quickly, and once it has been achieved it continues.

It may be argued that heterozygosity implies a power of adaptation on the part of the individual to a changing environment. It seems to be the case that the homozygous individual is not relatively so plastic. This may be a matter of considerable importance in the case of other forms, but man can control his environment much more easily than he can control his hereditary constitution. It is far simpler to warm a room than to

impose a control upon one's own temperature-regulating mechanism. Moreover, how can one maintain that the lowly bacteria cannot and do not adapt themselves to changing environments? Indeed, they are remarkable for their powers of adaptation, and yet they reproduce asexually. It is interesting to note that if mankind reproduced asexually, then racial improvement would be a simple matter, if only certain selected individuals were permitted to reproduce themselves. Heterozygosity associated with sexual reproduction certainly yields fascinating variety in the matter of combinations of hereditary characters, but the association certainly prevents the easy perpetuation of the desirable and permits the appearance of the definitely undesirable, judged by any standard, in increasing numbers.

An examination of the postulated intimate connection between sexuality and reproduction, then, fails to demonstrate that such a connection exists in fact. Furthermore, sexuality does not seem to possess any real advantage over asexuality in the matter of reproduction.

It would seem that the personal value of the sexual act is not necessarily reduced after sterilisation. The "change of life" or menopause in women marks the cessation of those activities on the part of the ovaries which lead to the production of ova, but though reproduction thereafter becomes impossible, the personal enjoyment in sexual congress is not necessarily thereby decreased. In the case of the male, castration in the adult is not followed by an inability to perform the sexual act, though certainly it renders fertilisation impossible. It can be shown that sexual activity without reproductive activity is as possible as reproduction without sex. In the case of the man, the sexual act is the reproductive act: it is the actual ejaculation of the seminal fluid which gives the greatest sense of pleasure in the sexual act, and this ejaculate is the contribution of the male to reproduction. To prevent ejaculation is to avoid satisfaction: to avoid the reproductive act is to obliterate much of the sexual act. But in the case of the female the sexual act has nothing whatsoever to do with the reproductive act, for coitus is not attended by the discharge of ova. In her case sexual satisfaction is achieved through the stimulation of nerve endings in the genital tract by the copulatory organ of the male, and ovulation—the discharge of ova from the ovaries—does not occur until some hours later, as in the rabbit, or else it has no relationship whatsoever to coitus. In the human female, ovulation occurs periodically and unconsciously during the period puberty-menopause, both in wife and in virgin, and coitus has nothing whatever to do with this process. There is no reason for assuming that the extrusion of an ovum is in any way a conscious or a pleasurable event. The pleasure of sexual activity has no relation to reproduction. It is present whether coitus is fruitful or abortive.

It may be argued that sexual activity is really associated with reproductive activity in the human female for the reason that sexual activity is associated with the reception, if not with the extrusion, of gametes. But such a contention cannot be maintained. Masturbation can replace coitus, and it can be shown that sexual satisfaction on the part of the female is not necessarily attended by the reception of the gametes of the male. The only possible relation would seem to be that sexual activity in the female permits her to exhibit her reproductive function.

The search for a definition of sex would seem to be hopeless. It has been shown that one cannot refer it to the relationship of two individuals, these being either dissimilar or similar in characterisation. It is true that in the case of man and of domesticated animals the sexual act is an *affaire à deux* in which two dissimilar individuals, a male and a female, play different rôles. But this is not all, for following intercourse there is a definitely sexual interaction between the gametes, the ovum and the sperm. These are as dissimilar in their form and function as are the bodies which elaborate them. There is thus a sexuality of the individual and also a sexuality of the gamete. It is the case that usually the sex of the individual is in accord with the sex of the gamete elaborated by that individual, but it can be shown that the sexual characters of the individual are not dependent upon the type of gametes which the individual elaborates. Experimentation has shown that the general appearance and behaviour commonly regarded as typical of maleness are exhibited even in cases in which the tissue of the testis, which is responsible for the production of spermatozoa, has been destroyed, and similarly that the typical female characters persist after the production of ova by the ovaries has been rendered impossible. The production of spermatozoa is only one of the characters which, in their combination, comprise the state or quality of maleness ; it is not the cause of maleness ; and therefore the sexuality of the gamete and the sexuality of the individual must be considered separately.

Biologists have applied the term " sexual activity " to so very many and such varied phenomena, that any exact definition is difficult. However, there would seem to be general agreement that sexual activity is that particular activity exhibited in the mating of male and female, being the force which impels the individuals to mate. But, as has been said, the modes and methods of mating are exceedingly varied. In certain forms male and female do not exhibit any mutual activity in mating. Each, apparently without reference to the other, merely extrudes its gametes and these, disseminated through the water, meet and mate, that is to say, that dissimilar gametes mate but that sexual individuals do not. Now, such a meeting and mating of gametes is just as much a sexual act as is the meeting and mating of male and female individuals. Manifestly, the mating of individuals cannot be a criterion of sexuality. It has been shown that sex-dimorphism—the existence of structurally different male and female forms within a species—is not, as would appear to be the case at first sight, fundamental to sex. There are no sexes in the common earthworm or in the common snail. All individuals are alike in respect of sex-equipment, each possessing both ovaries and testes, and each producing both ova and spermatozoa. Nevertheless, the individual does exhibit sexual activity for, having reached a certain stage of its development, each seeks out a mate—another individual exactly like unto itself—and the two join in sexual intercourse, each fertilising the other. In forms such as this one cannot speak of the mating of the sexes, but only of the mating of two individuals. It is even more difficult to fit into the conventional picture of sex forms such as Spirogyra. This is a plant which has the form of long green threads, anchored to the bottom of ponds and slowly flowing streams. Every thread is subdivided into many component cells,

and should two such threads come together after they have reached a certain stage in development, it may be seen that some of the cells send out protruding feelers which enter cells of the adjoining thread. Moreover, it is possible to distinguish between the passive cell which receives the feeler and the active cell which sends these out. One might refer to the passive cell as being the female and its mate as the male cell in this relationship. By experiment one can distinguish between threads, all the cells of which under these conditions extrude feelers, and other threads, all the cells of which receive these; that is, one can distinguish between male threads and female threads. But should one keep two female threads together, one or other of them will behave as a male toward its companion. The explanation offered to accommodate these and other facts is that these threads are weakly or strongly sexed. A " weak " male behaves like a female in its relationship with a " strong " male, or as a male to another male " weaker " than itself. Manifestly, the meaning of maleness and femaleness loses much of its clarity. The relationship of thread and thread can better be understood if one merely states that the strength of the sex of these threads varies and that the more strongly sexed thread behaves as a male toward the weaker sexed thread, and that the weaker sexed thread behaves as a female toward the more strongly sexed thread. The suggestion that is conveyed by these experiments is that the sexuality of an individual is not absolute but relative.

Should one seek for some feature common to all these instances, one must conclude that sex is not necessarily expressed in the form and in the appearance of the individual, but in its behaviour and reactions under certain conditions. It is the stimulus which excites sexual activity that varies as one passes from form to form; but the method of the response to this stimulus would seem to be common to all. In heterosexuality, the stimulus that lights up sexual activity is the person or the image of another individual of the opposite sex. In homosexuality, the sexuality of the individual is released and stimulated by the presence of an identical individual. There are other forms, in which both ova and sperm mature within one and the same body and are extruded together, and in which this extrusion of gametes is not in any way dependent upon the presence of another individual. Yet such extrusion is a sexual act, and there may be observed during its occurrence every sign which is associated in other forms with the congress of two differently sexed individuals. Intense excitement, followed by calm, would seem to be the hall-mark of sexuality in its expression in all forms, either hetero-, homo-, or auto-sexual.

This imperfect discussion of the nature of sex must presently suffice. One leaves the subject with a feeling of regret that biologists and laymen could not be content to leave the nature of sex unexplained and to accept some simple point of view as that of Plato, who held that in the beginning man and woman were one, but that they were divided by the wrath of the gods into two, who for ever tend to come together and unite again. Such a view at least expresses the fundamental character of sexuality.

It is necessary next to discuss the nature of those factors which determine whether any given organism shall develop into a male or else into a female. This question is usually known as the determination of sex. Before passing on to it, however, it is desirable briefly to discuss the origin of the individual itself. This story, as does everything else in the history of biology, begins with Aristotle, the first biologist whose published works we possess in complete form. This great teacher divided animals into two classes—those which developed without parents, directly from unorganised matter by means of spontaneous generation, and those which came into being through sexual reproduction, each of the parents contributing something to the offspring. According to him, the ejaculate or semen of the male did not originate in the testes; the true function of these organs being to delay emission of the male ejaculate until it had had time to ripen. In the female it was not the uterus (womb) or the oviducts (the tubes which lead from the uterus to the vagina, L. *ovum*=egg; *ducere*=to lead) which provided the maternal contribution to the next generation, the material which was contributed being the menstrual blood. The process of reproduction consisted in the mixture of the menstrual blood and the male ejaculate, and in the development of an egg from this mixture. The female contributed the substance of the embryo, whilst the male contributed that formative impulse which initiated growth and determined form.

The ovaries of the mammalian female are solid bodies, quite unlike those of the bird, and were referred to by the earliest anatomists as "female testes." Galen supposed that the semen of the male was manufactured in the arteries and veins of the testes, and was thereafter sieved through these latter organs. The female semen, according to this authority, was likewise elaborated in the blood-vessels of the female testes, and the two fluids, male and female, became mixed in the uterus of the female, there to coagulate and then become frothy and thus evolve the embryo. For a thousand years this point of view prevailed.

It was not until William Harvey, greatly influenced by the previous observations of Fabricius, wrote his great book *De generatione animalium* (1651), that new concepts began to be considered. Harvey was the personal physician of Charles I, and this position provided opportunity for him to transfer his work from the incubating hen's egg to mammals. He was permitted to carry out a post-mortem examination of female deer, killed by the enthusiastic royal huntsman. Harvey found, quite unexpectedly, that the uterus of the deer, before November 12th (the date is of importance only in that it bears a relation to the normal mating season of the deer) in any of the years of his study, was completely empty, although its lining was swollen and softened. This observation supported neither the views of Aristotle (according to whom there should have been visible, during the first stages of generation, menstrual blood mingled with male ejaculate) nor those of Galen (according to whom there should have been visible a mixture of male and female semen). King Charles, interested in these findings, next permitted Harvey to have twelve does taken alive during the mating season. Some of these were killed soon after

capture, and again nothing was found within their uteri. The others were kept and later gave birth to their young. It appeared, therefore, that indeed for a fortnight, or even a month after conception, nothing existed in the uterus which the human eye could discover. But, about the 12th to 14th of November, Harvey noted the presence of white filaments, like spiders' webs, becoming conjoined and presenting themselves as membranous or gelatinous sacs, and a few days later the tiny embryo could be identified amid its membranes. From these observations Harvey concluded that the spermatic fluid did not reach the uterus, but exuded an effluvium which stimulated the uterus to secrete the egg.

Another generation elapsed before further discoveries were made. Swammerdam and van Horne of Leyden developed the idea that the " female testes " of the mammal were comparable to the ovaries of birds, like them producing eggs. The same idea was included in a thesis of Stensen (1667), but whilst these were continuing their studies a third student of the Leyden group, de Graaf, published in 1668 a book which anticipated many of the points that were still being considered by the others. A later book, *De Mulierum organis generationi inservientibus* (1672), by the same author, contained a full description of the genital tract of the human female and the first real account of the ovarian follicles. He was of opinion that the whole content of the follicle was the ovum, and that what we now know as the *corpora lutea* (yellow bodies) developed in the follicular wall before the rupture of the follicle. Using the rabbit as his experimental material, de Graaf found nothing in the genital tract of those which he killed on the first or second day after mating, but on the third day he found tiny spherical bodies in the Fallopian tubes (*see Fig.* 1), and on the fourth day slightly larger spheres in the uterus. He rightly regarded these as the products of the ovary, and the forerunners of the embryos. It is interesting to note that no one else succeeded in finding embryos in the uterine tubes again until more than a hundred years had passed.

A few years later (1677) Leeuwenhoek discovered the spermatozoon in a drop of fluid obtained by one of his students from a patient suffering from a urethral discharge. Observations made on other animals revealed the presence of these animalculæ in the seminal fluid of all of these. Leeuwenhoek promptly concluded that the spermatozoon was the whole material contribution to the embryo from its parents, and that the uterus of the female was simply the place where the spermatozoon was incubated and was nourished. He denied the importance, even the existence, of the egg. Leeuwenhoek's view that the spermatozoon was the rudimentary embryo was carried to absurd lengths by his followers, one of whom published a picture of a homunculus—a miniature man—which he had observed in the seminal fluid and which had the outward appearance of a spermatozoon but which, on closer examination, revealed all the characteristics of a minute human being with folded arms. From this it was deduced that within the testes of this homunculus there was a still smaller homunculus and so on, *ad infinitum*; Adam, the first man, therefore, must have contained within his reproductive system all the generations that could follow him, enclosed one within another like the unending boxes of a Chinese puzzle.

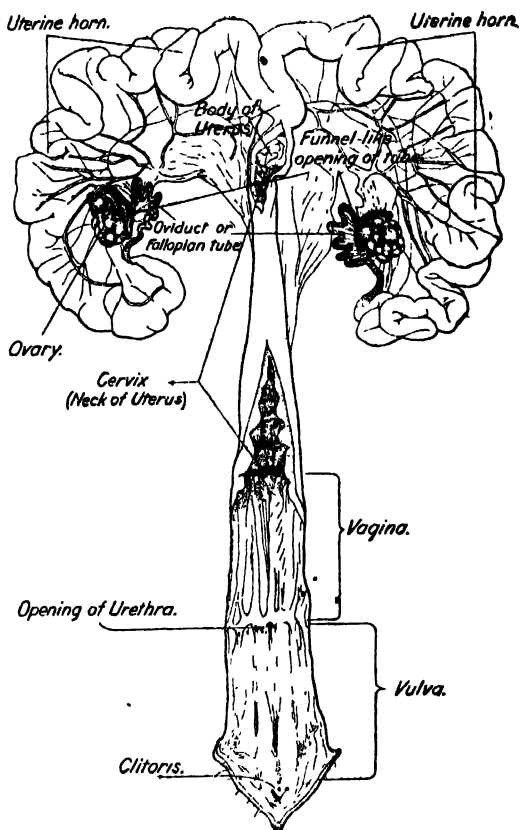


Fig. 1. GENITAL ORGANS OF SOW

The ova develop within the solid ovary. As each ovum ripens it becomes enclosed with a follicle containing fluid—the *liquor folliculi*—and moves toward the surface of the ovary. In the diagram the follicles are seen as grape-like clusters. As the ovum ripens, this fluid increases in amount until the pressure within the follicle is such as to cause a rupture of the follicle wall which is exposed on the surface of the ovary. The ovum is extruded and passes into the mouth of the Fallopian tube and onwards into the uterine horn. The wound on the surface of the ovary, thus produced, heals, and the scar tissue is peculiar in that it is yellow in colour and glandular in structure. Such a mass of scar tissue is known as a corpus luteum which elaborates specific chemical substances that play their part in the maintenance of the state of pregnancy.

The ejaculate of the male is deposited in the upper part of the vagina, and the spermatozoa make their way upwards through the cervix (the neck) of the uterus into the body of the uterus and on into the uterine horns. It is here that sperm and ovum meet and that fertilisation takes place.

The fertilised ovum becomes embedded in the wall of the uterus and proceeds to develop into embryo and fœtus. At the time of birth the neck of the uterus dilates and the muscular action of the uterus expels the fœtus *via* the vagina to the exterior.

Fifty years later von Haller (1752) carried out embryological studies of sheep, after the manner employed by Harvey in the case of the deer. The results he obtained confirmed Harvey's opinion that nothing was to be found in the tubes during the first part of pregnancy, and he concluded that something of an undefined character passed from ovary to uterus and there slowly coagulated into the ovum. In 1778 William Cruikshank, an assistant to William Hunter, repeated this work, using the rabbit. Cruikshank had no difficulty in finding ova in the Fallopian tubes on the third day after mating, and in the uterine horns (*see Fig.* 1) thereafter. Thus the work of de Graaf was confirmed 106 years after the publication of his results.

Then came two young men of Geneva, Prevost and Dumas, who demonstrated (1824) that complete spermatozoa were to be found in the testes, and that these organs were the site of their origin. Next they showed that by mixing the eggs and the sperm of frogs, tadpoles could be produced, but that if filtered spermatic fluid, or the vapours arising from the spermatic fluid, were used the eggs were not fertilised. Furthermore, they demonstrated that, after copulation, spermatozoa could be found in the uterus of the dog. This was the first observation of this fact, and constituted a conclusive refutation of Harvey's notion that nothing passed from the male into the upper portions of the genital tract of the female. Later they found in the uterus very small bladder-like bodies, like those noted by de Graaf and Cruikshank in the uterus of a rabbit. Since they expected to find very much larger bodies than those which they found, they concluded that the large ova of the ovaries—that is the Graafian follicles—contained small ovules. But when they examined the follicles in the ovary of the bitch, they did not find any of the small clear vesicles which they expected to see. But it is recorded that on two occasions they did observe minute opaque round bodies, the very objects for which they were seeking, but they dismissed them from any consideration.

The two men parted shortly after this work was completed, and their opinions developed somewhat divergently. Prevost gave it as his opinion that spermatozoa and ova together yield the embryo; but held the view that neither of them formed any part of the actual tissues of the embryo. He seems to have thought that the sperm and the egg interacted to secrete the embryo in the uterus. Dumas on the contrary believed that the spermatozoon, having united with the ovum, became the nervous system of the embryo, the ovum contributing the rest.

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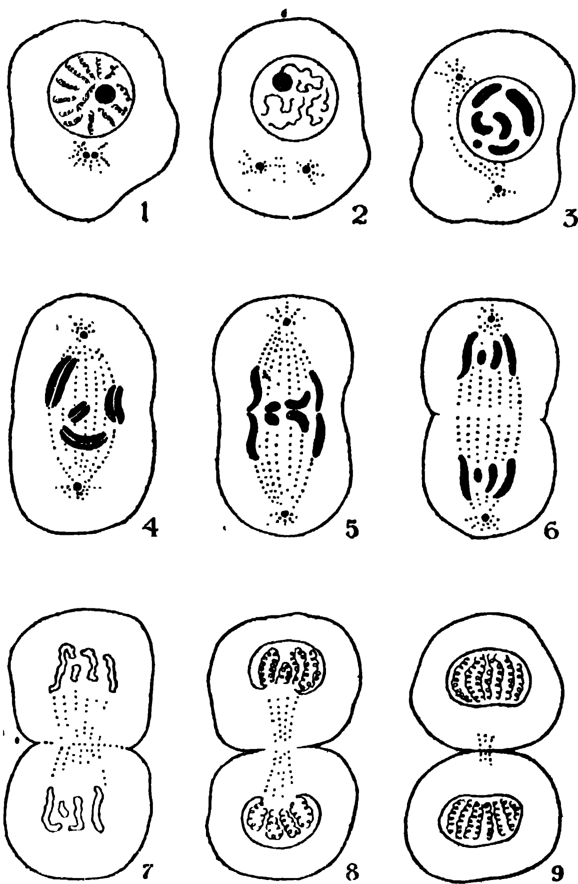


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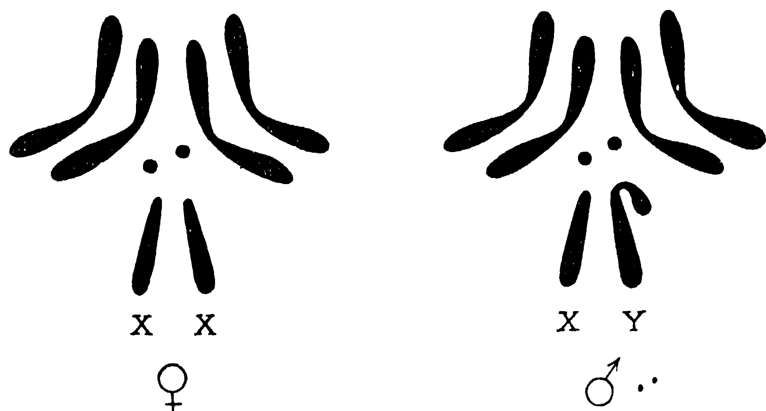


Fig. 3. CONVENTIONAL DIAGRAM OF THE CHROMOSOMES OF A FLY, *DROSOPHILA MELONOGASTER*

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Fifty years later von Haller (1752) carried out embryological studies of sheep, after the manner employed by Harvey in the case of the deer. The results he obtained confirmed Harvey's opinion that nothing was to be found in the tubes during the first part of pregnancy, and he concluded that something of an undefined character passed from ovary to uterus and there slowly coagulated into the ovum. In 1778 William Cruikshank, an assistant to William Hunter, repeated this work, using the rabbit. Cruikshank had no difficulty in finding ova in the Fallopian tubes on the third day after mating, and in the uterine horns (*see Fig.* 1) thereafter. Thus the work of de Graaf was confirmed 106 years after the publication of his results.

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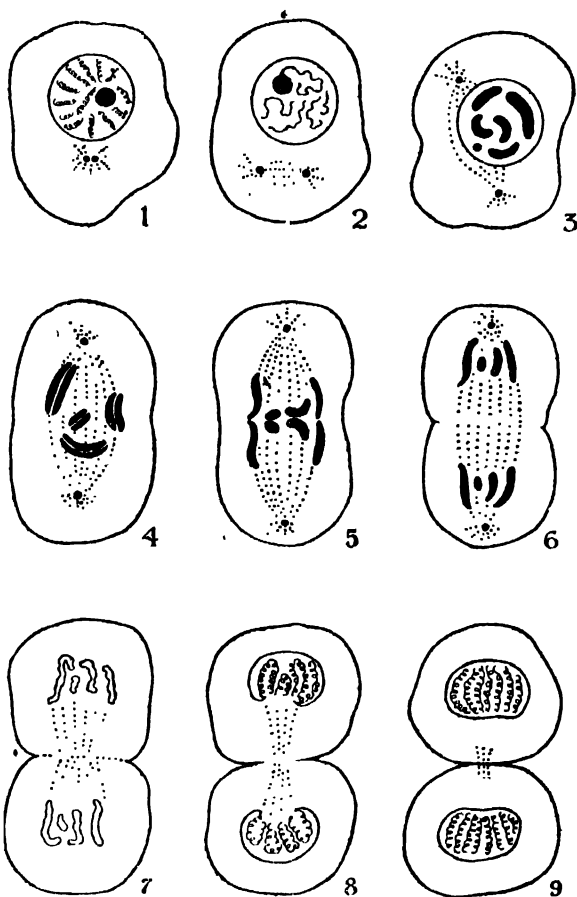


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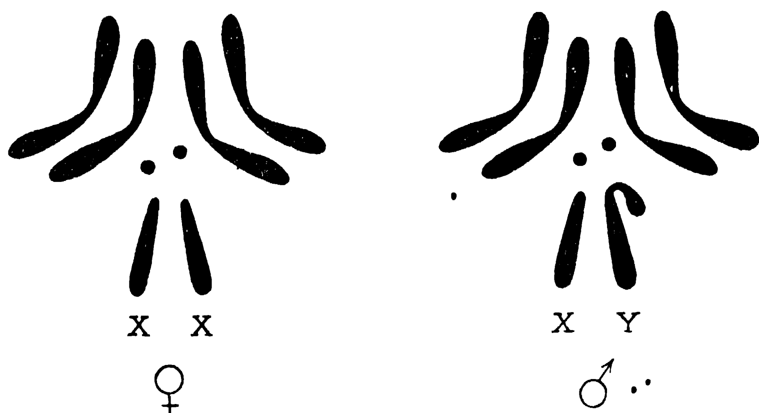


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the sexes differ are referred to as the *sex-chromosomes*, in contrast with the rest which are known as the *autosomes*, and the individual sex-chromosome itself is known as an X-chromosome. In many forms the difference consists in the presence of a pair of identical members in one sex (XX), whilst in the other there is a single X and an unequal mate, the so-called Y-chromosome. In these cases, then, male can be distinguished from female for the reason that in all the cells of the body and in the unripe gametes of the former, there is either a single X, or else an X and a Y, whilst in the case of the latter each cell of the body and each unripe egg contain two X-chromosomes.

It is established that in the ripe gamete, egg or sperm, there is to be found one member of each pair of homologous chromosomes which are present in the cells of the body and in the unripe gamete. This reduction

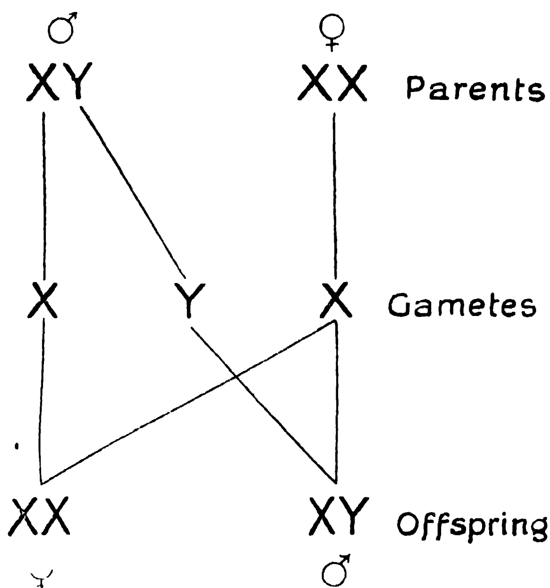


Fig. 4. THE SEX-CHROMOSOME SEX-DETERMINING MECHANISM

in the number of chromosomes is effected by what is known as the "reduction divisions" during the formation of the gametes. These do not occur during ordinary cell-division whereby the body, its organs and tissues, increase in size or effect repair; they are special divisions during gametogenesis. Before a cell divides into two there is a previous longitudinal division of the chromosomes (*see Fig.* 2. 4), that is to say, there is multiplication of the chromosomes, and of each original chromosome one half passes into each of the two daughter cells (*see Fig.* 2. 6). As a result, each receives that number of chromosomes which is characteristic of the species. But in gametogenesis, instead of each chromosome

dividing into two, the two members of each pair of homologous chromosomes fuse. So that on examination there would appear at this stage to be only half the correct number of chromosomes. Later the two members of each pair separate and one passes into each daughter cell. Thus each of these will come to contain only half the number of chromosomes which is characteristic of the species.

It follows, therefore, that in each egg there will be one X-chromosome, whereas in the case of a species in which the male is XY in sex-chromosome constitution there will be two sorts of spermatozoa, one including an X- and the other including a Y-chromosome. The male is *digametic* in these forms, the female *monogametic*. The new individual has its origin in the union of egg and sperm. It can therefore have its beginning in the union of an X-bearing egg with an X-bearing sperm, and become an XX individual (a female), or else in the union of an X-bearing egg with a Y-chromosome bearing spermatozoon to become an XY individual (a male) (*see Fig.* 4). This sex-determining, sex-chromosome-distributing mechanism yields results which are entirely in accord with observed facts, and the list of species in which this sex-chromosome distinction between the sexes has been found to exist is enlarging yearly.

That sex is determined at the time of fertilisation and by means of this sex-chromosome, sex-determining mechanism is supported by the facts of what is known as sex-linked inheritance. In the case of a species in which the male is XY in sex-chromosome constitution and the female XX, the son, who, to be a son, must receive one X-chromosome and one Y, must get his single X-chromosome from his mother, since it is the Y that he will receive from his father; whilst the daughter must get one X from each parent. If on the X-chromosome of the father is borne the hereditary factor for a recessive character, then the track of this chromosome in inheritance can be followed if the Y-chromosome of the male carries no hereditary factors which in any way affect the action of those borne upon the X. Colour blindness—the inability to distinguish between red and green—is an example of a sex-linked recessive character. If a colour-blind man marries a normal-sighted woman, then the sons of this marriage will all be normal, but the daughters, though normal themselves, will carry the hereditary factor for this abnormal condition. Should a colour-blind man marry a daughter of such a marriage, then of the sons 50 per cent. will be colour-blind and 50 per cent. will be normal, whilst of the daughters 50 per cent. will be colour-blind and 50 per cent. will be carriers. If a carrier woman should marry a normal man, then of the sons 50 per cent. will be colour-blind and 50 per cent. normal, whilst of the daughters, 50 per cent. will be carriers and 50 per cent. normal. These statements refer to observed facts.

By means of this scheme the reader can for himself predict the distribution of colour-blindness among the offspring of any marriage. Let X underlined so, $\underline{X}$, indicate that on this X-chromosome the factor for colour-blindness is borne. There can thus be two kinds of males, colour-blind males, $\underline{X}$Y, and normal males, XY. But, there are three kinds of women; colour-blind, $\underline{X}\underline{X}$; carrier women, $\underline{X}$X; and normal women, XX. A carrier of a recessive character is an individual in whose hereditary constitution there lies hidden the factor for this particular character.

It is not expressed because it is covered by the dominant character of normality. Thus, on one X-chromosome of a woman, a carrier of colour-blindness, there is this factor (X), but on the other, the alternative factor for normal vision is present. If a woman is to be colour-blind, she must have a double dose of this colour-blind factor: for a man to be colour-blind, he needs but one, for the reasons that he has only one X-chromosome and that on the Y-chromosome there is not the factor for normal vision.

These and similar facts can be explained easily and satisfactorily if it is assumed that the hereditary factor for colour-blindness is resident in the X-chromosome, that the presence of one X-chromosome in the chromosome constitution of an individual leads to the development of maleness, whilst the presence of two X-chromosomes leads to the development of femaleness, and, finally, that the sex of the individual is determined at the time of fertilisation by the workings of this sex-chromosome-distributing mechanism.

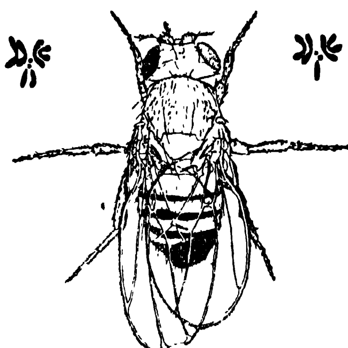


Fig. 5, A LATERAL GYNANDROMORPH *DROSOPHILA MELONOGASTER*

The left side is red-eyed and female in type; the right side is white-eyed (a sex-linked recessive character) and male in type. The cells on the left side contain two X-chromosomes; those on the right side contain only one. Since the mother of this fly was white-eyed and the father red-eyed, and since red is dominant to white, we are enabled to state that it was the X-chromosome from the father that was lost.

The very clearest light is thrown upon this sex-determining mechanism by what is known as gynandromorphism in insects (Gk. *gyne*=woman; *aner*=man; *morphe*=form). A gynandromorph is an individual which is a sex mosaic in space, exhibiting both male and female characters. In a lateral gynandromorph half of the body is male, the other half is female. It has been shown that this abnormality in the regional distribution of the sex characters is associated with, and can be explained by, an abnormality in the distribution of the X-chromosomes. The gynandromorph is an individual which has its origin in the fertilisation of an X-chromosome-bearing egg by an X-chromosome-bearing sperm to become a genetic female—XX in sex-chromosome constitution. The fertilised egg in which this individual has its origin becomes the individual by continued

cell division. First of all the egg divides into two, and this division involves a previous longitudinal division of all the chromosomes, which, as has been said, exist in the form of pairs, and of each pair one member has come by way of the sperm from the father, the other by way of the egg from the mother. As a result of this division of the chromosomes, each daughter cell receives exactly that number of chromosomes which is characteristic of the species. Each of the X-chromosomes of the fertilised egg divides longitudinally and into each daughter cell there passes one half of each. If at this first division of the fertilised egg one of the daughter X-chromosomes fails to pass into one of the daughter cells, then that cell and all its descendants will contain only one X-chromosome instead of two. Furthermore, if in respect of sex-linked characters the father and the mother differ, it becomes possible, by reference to the characterisation of that half of the body the cells of which contain only one X, to recognise which X, paternal or maternal in origin, has been eliminated. Examination of the tissues of such a lateral gynandromorph

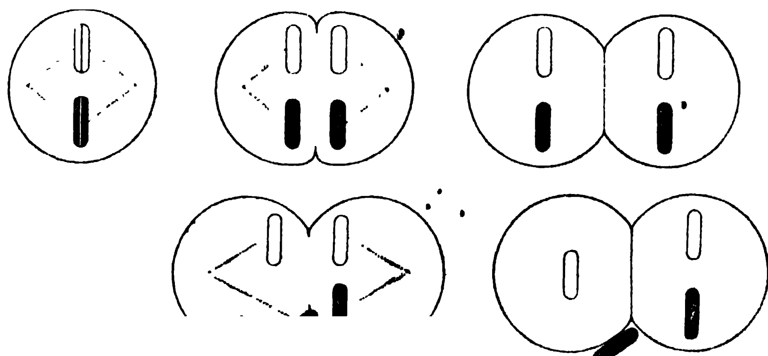


Fig. 6. DIAGRAM ILLUSTRATING THE CAUSE OF GYNANDROMORPHISM

Above is shown the normal distribution of the X-chromosomes; below is seen the daughter X-chromosome excluded from the daughter cell.

has shown that this explanation is the correct one, for the cells of the male half of the body include only one X-chromosome, whereas the cells of the female half include two. It is interesting to note that of the two sides of the body in the case of these forms one has its origin in one of the daughter cells produced by the first division of the fertilised egg, the other half having its origin in the other daughter cell (*see Fig.* 6).

From this and other evidence it follows that in the body cells of the female tissues there are two X-chromosomes in association with two of each of the autosomes, so that, if A represents one complete set of autosomes as present in the ripe ovum, the quantitative relation in the body cells and in the unripe gametes between the sex-chromosomes and the autosomes can be expressed by the formula 1X : 1A; whereas in the male the relation of X-chromosomes to autosomes is expressed by the formula 1X : 2A.

For purposes of discussion, by far the simplest method of constructing

a thought model of the sex-determining mechanism is to assume that on the X-chromosome of these forms are hereditary factors that are female-determining, and that on the autosomes are others that are male-determining, and that the sexuality of the zygote is determined by the balance between these. If F represents one set of such female-determining factors on the X-chromosome, if M represents one set of the male-determining factors on one set of the autosomes (A), and if in their relationship 1F is greater than 1M, but less than 2M, then

(FX) (FX)MM is a female because 2F is greater than 2M; whereas
(FX)Y(MM) is a male because 1F is less than 2M.

A complication enters here. In the moth and the bird it is the female and not the male that is digametic. Symbolised, her sex-chromosome constitution is XY, and that of the male XX. In these cases it is necessary to place the male-determining factors on the X and the female-determining factors on the autosomes, so that

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These formulæ, of course, must not be taken too literally. They are to be regarded as simple attempts to explain a very imperfectly understood subject concerning which there is presently profound lack of physiological knowledge. But it is certainly necessary to postulate that in every zygote, be it XX or XY in sex-chromosome constitution, there are the physical bases of developmental impulses which strive to impose upon the developing individual a male type and a female type of differentiation respectively.

This is clearly shown by the results of crossing different geographical races of the gypsy moth *Lymantria dispar*. It has long been known to entomologists that when these are crossed sexual abnormalities are commonly present amongst the hybrid offspring. For example, if European specimens of the gypsy moth are bred amongst themselves, their offspring are perfectly normal in every way. The same is true of the Japanese variety. But should a Japanese male be mated with a European female, the offspring consist of normal males and of females that are intersexual in that they show a number of modifications in the direction of maleness. The reciprocal cross, European male and Japanese female, yields normal males and females, but if the individuals of this generation are interbred, then, in the next hybrid generation, there appear a proportion of males that are intersexual, that is, that show modification in the direction of the female type of sex-equipment. This problem has been studied very thoroughly by Goldschmidt of the Kaiser Wilhelm Institut für Biologie, Berlin-Dahlem. He has found that in respect of their ability to produce intersexual forms when crossed, there are very many different races of European, Japanese and American gypsy moths. As a result of great numbers of matings between different races, Goldschmidt has been able to classify his strains as relatively "strong" or "weak." For example, a strong male mated to a weak female would give 50 per cent. normal males and 50 per cent. intersexual females. A very strong male mated to

a weak female would give offspring all exhibiting the male type of sex-equipment. Out of his experience there came to him the possibility of predicting the results of any particular cross, and to produce every grade of intersexuality. It was noted that this intersexual condition did not affect all the structures of the sex-equipment equally, and he found that he could arrange the different structures in a definite series as regards the degree of intersexuality, and that this series was exactly the opposite to the order of the time of their appearance in development. Those structures which were the first to be developed were the last to become modified : those that were developed last were the first to be changed. In order to explain these facts, Goldschmidt postulated that each individual possesses the potentialities of either sex, since each can become intersexual. The sex-chromosome constitution of the female is XY ; that of the male XX. He places the female-determining factors in Lymantria on the Y-chromosome of the female, and was forced to postulate that these factors elaborated their female-determining substances in the immature egg before the X- and the Y-chromosomes became disjoined. (It will be remembered that the immature gamete possesses a pair of sex-chromosomes, but that the ripe gamete includes but one single sex-chromosome. In this case the ripe egg contains either an X or else a Y.) Because the female-determining factors of the Y function before the egg has become finally ripe, substances, possibly enzymatic in nature, elaborated by the female-determining factors, pervade the immature egg and therefore pervade also both the final egg including an X-chromosome and that containing the Y. He places the male-determining factors on the X-chromosome. Furthermore, he postulates that since the different races can be classified as relatively " strong " or " weak " in respect of their sex-determining powers, these male-determining and female-determining factors themselves must vary in their relative strength. This concept can be illustrated in a simple fashion.

If F represents the female-determining factors borne upon a Y-chromosome, then to this F can be assigned a numerical value : *e.g.* F_5, F_4, F_3, F_2, F_1. Similarly, if M represents the male-determining factors carried by an X-chromosome, then the relative strengths of different male-determining factors can be represented by M_5, M_4, M_3, M_2, M_1. It will be noted that the female-determining impulses are always received by way of the egg from the mother. It follows, then, that in respect of the strength of the female-determining impulses all eggs of one and the same female will be alike. The female will receive her X-chromosome, and therefore her male-determining factors, from her father. The male possesses two X-chromosomes and therefore two sets of male-determining factors (M), and one of these will have been received from either parent, and these themselves may differ one from the other in respect of their strength. A male has its origin in an egg, and therefore into this egg will have passed the elaborated products of the female-determining factors of his mother. His constitution can be represented therefore by MMF ; the constitution of the female by MF. We can now give to these sex-determining factors numerical values. For example, consider the following mating :

(a strong male) $M_5M_5F_6$ × (a weak female) M_2F_3

The spermatozoa provided by the male will each contain M_5 (no female-determining factors will pass into these gametes for the reason that according to the argument these come only by way of the egg). The gametes of the female, on the other hand, will be of two kinds: those with an X-chromosome which will have the constitution M_2F_3, and those without an X-chromosome which will have the constitution F_3. Fertilisation will result in the appearance of two kinds of offspring—$M_5M_2F_3$ (a male because there are two X-chromosomes and because $5 + 2 = 7$, and 7 is greater than 3: because, that is, M is greater than F); and genetic females, XY in sex-chromosome constitution, but, since 5 is greater than 3, they will all possess the male organisation (that is, they will be examples of complete sex-inversion of females into males).

The simplest method of envisaging what is happening is to assume that the different strengths of male- and female-determining factors elaborate their products at different rates; that an M_5, for example, as compared with an M_2, is a male-determining factor which elaborates its products much more quickly. If this is so, and if the relation of male- and female-determining factors can alter during that period of development when the sex-equipment is being laid down, then one can accommodate all the facts by what is known as the time law of intersexuality. In the normal male M is always greater than F during that time of the individual's life when the sex-equipment is being laid down. In the female F is always greater than M. But if it should so happen that these sex-differentiating substances are produced at different rates, then there exists the possibility that sex-mosaics in time will be produced. If, for example, in the case of a female, the male-determining reactions should operate at a greater rate than do the female-determining reactions, then the former may overtake and finally supplant the latter. If there is a serial order in the events of sex-differentiation, that is to say, if one can make a time-table representing the relative time of appearance of the various characters of the sex-equipment, then the degree of intersexuality will be determined by the time during this process of differentiation of the sex-equipment when one type of sex-differentiating reaction overtakes and replaces the alternative type. An intersexual female is a female which has pursued a normal female development up to a particular point, but which thereafter switched over and pursued a male type of differentiation. According to this hypothesis it is not the absolute but the relative rates of production of male- and female-differentiating substances that control and model the sex-equipment. It is to be noted that not every part of the body is involved in this condition. Only the structures of the sex-equipment are concerned, and of these only those whose differentiation is not complete at the time are affected by the switch-over. The earlier in development the switch-over occurs, the more structures of the sex-equipment will be affected, and therefore the greater will be the degree of intersexuality. Intersexuality of this kind is the result of a quantitative disharmony between the male and the female sex-determining factors. It is inborn, for it is nothing more or less than the expression of the hereditary constitution of the individual. If the seeds of this disharmony are in the fertilised egg, then inevitably this kind of intersexuality will become expressed as development proceeds.

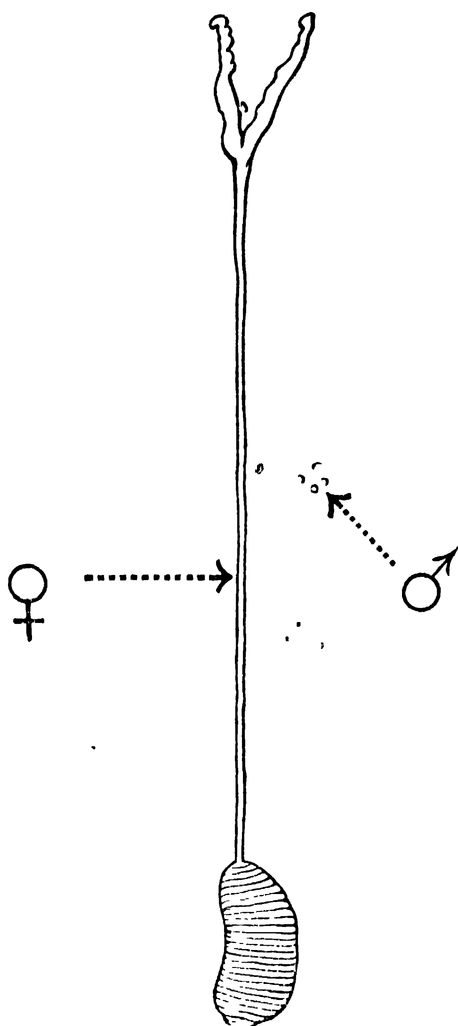


Fig. 7. BONELLIA

Intersexuality very similar in its general appearance can, on the other hand, be the result of the overwhelming of the hereditary constitution of an individual by the impress of external agencies. Bonellia is a marine organism in which sex-dimorphism is most pronounced. The female has a bulky bean-shaped body about two inches long, and extending from one pole of this there is a very long tube-like proboscis ending in a bifurcation (*see Fig.* 7). She rests at the bottom of the water with her body hidden amongst stones and her proboscis protruding in search of food. The male is a microscopic pigmy consisting of nothing but reproductive organs. He

lives within the reproductive passage of the female, obtaining from her everything that he needs for life and in return fertilising the eggs that she produces. The young Bonellia is a free swimming form, floating on the surface of the waters, and amongst them there is no sex-dimorphism, all the individuals are alike. As they develop they begin to sink toward the sea bottom, and the sexual fate of the individual is determined entirely by chance. If one should settle on or near the proboscis of a female it becomes a male. If, on the other hand, it settles at a distance far removed from a female, it becomes a female. If an individual which has been in

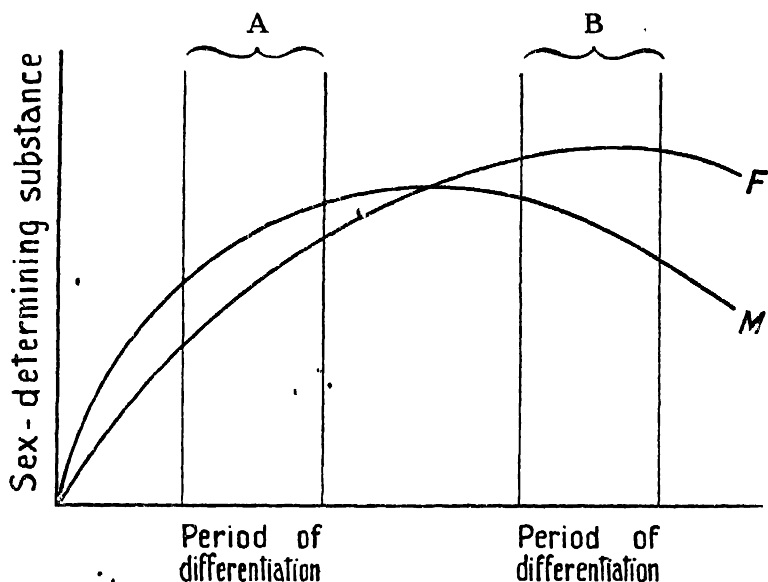


Fig. 8.

If the differentiation of the sex-equipment occurs early (A), then it is pursued under the influence of the male-determining reactions; if it occurs later, then it comes under the influence of the female-determining reactions. The effect of the stimulus of the female's proboscis is to cause the sex-equipment to be differentiated as A.

contact with the proboscis of a female for a time, and which is therefore developing the male characters, is removed and kept apart from a female, the mode of differentiation changes and the sex-characters which are still to be developed are those of a female. Extracts made from the proboscis of females and added to the water in which larval forms are living induce a male type of differentiation in these.

It may be assumed that Bonellia, like Lymantria, has a sex-chromosome, sex-determining mechanism, but it is seen that even though this be the case the determination of sex is not effected thereby. The facts have been explained as follows. During the early stages of development

in Bonellia, the male-determining reactions are effectively in excess of the female-determining reactions. A little later, however, the female-determining reactions gain the ascendency. If this be so, then if the differentiation of the sex-equipment of the individual occurs early in life, it will take place under the control of the male-differentiating reactions. If, on the other hand, the differentiation of the sex-equipment is somewhat delayed, then it will occur under the control of the female-differentiating reactions. The effect of the chemical substances contained in the proboscis of the female is to produce a precocious development of the sex-equipment, so that any individual exposed to the action of these substances will develop a male characterisation; whilst any individual which is not exposed to their action will become a functional female (*see Fig.* 8).

Broadly it can be stated that in many forms sex is determined solely and finally by the workings of the sex-determining, sex-chromosome-distributing mechanism; whereas, in other forms, the action of this mechanism is conditioned by, and can be overwhelmed by, the impress of external agencies.

THE SEX-HORMONES

In its beginning, the male amongst mammals has a hereditary constitution which is represented by the formula XY and the female by XX. At this stage the individual is but a fertilised egg, and much must happen before it can become a functional male or functional female possessed of the appropriate characterisation. With development there comes the laying down of the sex-equipment, and at the end of development one can be distinguished from the other by differences in anatomical structure, in physiological functioning and in mental characterisation. In the vertebrates (back-boned animals) this initial sexuality, which is but the direct expression of the action of the hereditary factors, is strongly reinforced when the sex-glands of the individual have become differentiated. At this stage of our knowledge it must content us to assume that the normal male develops testes for the reason that in the beginning he had a hereditary constitution which we can symbolise as 1X:2A, and because, during the time of his development, the male-determining reactions were always effectively in excess of the female-determining reactions. Similarly, we must assume that a female develops as a female because in the beginning she had a hereditary constitution which we can symbolise as 1X:1A, and because during her development the female-determining reactions were always effectively in excess of the male-determining reactions.

The results of experimental castration, and of implantation of testicular and ovarian tissues, have demonstrated clearly the intimate relation between the type and the degree of the sex-characterisation on the one hand, and the structure and functional activity of the sex-glands on the other. The stag bears horns, and his accessory sexual apparatus includes penis and scrotum, and these are associated with the presence in his body of testes. In the hind the ovaries are associated with the presence of a uterus, well-developed mammary glands, absence of horns, or else a different pattern of horns, and different body shape. This association of various characters with testis and ovary respectively is so intimate, that

one has no hesitation in identifying the sex of an individual by reference to the structure of its sex-gland. Indeed it can be said that a female is a female in virtue of her ovaries ; a male a male in virtue of his testes.

These sex differences associated with differences in the type of sex-gland pervade the whole organism. It has been found, for example, that the cells which comprise the female body commonly are smaller than those of the male, that there is a difference in the rate of respiration, in the rate of the pulse, in the intensity of the metabolism (Gk. *metabole*= change), the constructive and destructive chemical changes occurring in living organisms, and in many other bodily functions which, at first sight, seem to have nothing to do either with the structural or with the functional characters of sex. That many of such characters depend for their existence and maintenance upon the normal functional activity of the sex-gland is shown in the clearest possible fashion by the results of experimentation. After removal of the sex-gland, changes can be noted in the form and degree of expression of those structures and functions which depend for their initial expression and maintenance upon this gland.

For a long time the view was held that the sex-gland produced its effects through its nervous connections with other parts of the body. Indeed, it was not until the middle of the last century that this attempted explanation of the intimate relation between the sex-gland and the general sex-characters was destroyed, as a result of critical experimentation. The cock, after castration, does not crow ; his comb rapidly diminishes in size, and becomes pale. But it was found that if pieces of testis were implanted under the skin of such an animal, the signs of castration did not appear, although the testicular grafts had no connection with the ducts which carry the spermatozoa toward the exterior and had no nervous connection with the rest of the body.

When first these experiments were carried out, the theory was propounded that the testicle must elaborate a substance which is secreted into the blood stream and is carried thereby throughout the body, thus reaching all organs, influencing them and directing their differentiation. That this conception was fundamentally correct is shown by the fact that within recent years it has been found possible to extract from the testes of domestic animals a substance which, when injected into castrated males, prevents the development of those changes which invariably occur after removal of the male sex-gland. This substance is known as " the male sex-hormone " (Gk. *hormao*= I excite). A hormone (a chemical messenger) is a substance elaborated by a glandular organ, passing therefrom directly into the blood stream and thus being conveyed to all parts of the body and stimulating or depressing the functional activity of distant organs. The male sex-hormone is regarded as being that particular elaborated product of the testis which is responsible for the expression and maintenance of the male characters.

Similar experiments have been carried out in the case of the female. It has been shown that a grafted ovary can maintain the general expression of femaleness in a female from which the ovaries have been previously removed. The injection of extracts derived from certain parts of the mammalian ovary induces the mating reactions in such ovariectomised mice, which otherwise would never attract or receive the male. It also brings

about complete development of the uterus and vagina and induces growth in the mammary glands. It follows, then, that functional sexuality in either sex is essentially a reaction on the part of the body to a particular sex-hormone, male or female.

As was to be expected, a very considerable amount of experimentation has been carried out, having for its object the demonstration of the results of the implantation of ovary into a male and of testis into a female, and of the effects of the injection of male sex-hormone into a female and of female sex-hormone into a male. It was Steinach, of Vienna, who first approached this problem. He used the guinea-pig as his experimental material, for the reason that in this form sex-behaviour is well differentiated in the two sexes and the differences between the external reproductive organs of male and female are very distinct, the male having a large penis with well-developed horns. His mammary glands are rudimentary with very small nipples. Steinach found that after removal of the ovary in the female the nipples atrophied, and that after castration in the male the penis either did not develop, or, if the operation was performed after it had become developed, it underwent atrophy. He found further that implantation of testicular material into the castrated male restored the normal male characterisation, and that implantation of ovarian grafts into the female restored the typical female sex-equipment. When he implanted testicular grafts into young ovariectomised females and ovarian grafts into young castrated males, he found that the male with no testes, but with ovarian grafts, developed large nipples, whilst its penis remained rudimentary. Furthermore, such an animal permitted the approach of young and actually suckled them. In its behaviour it in no way resembled the normal male. The female whose ovaries had been removed, and which had received testicular grafts, exhibited no female behaviour, but its clitoris developed into a penis-like organ.

Later investigators have found reason to qualify some of the original claims of Steinach, but that they are fundamentally correct cannot be doubted. One must conclude from this and similar work that the soma (Gk. *soma*=body), the general tissues of the body, of either sex can develop either male or female characters according to the type of sex-hormone with which it is supplied. The soma possesses the potencies of developing the characters of either sex. This is not surprising to anyone who is acquainted with the many forms which in Nature completely change their sex. The sword-tailed minnow, a fish commonly kept by fanciers, is remarkable in that many cases are known in which an old female has become a complete male. The oyster, it would appear, can undergo complete sex-transformation year after year. Complete transformation of male into female, and female into male, can be produced under experimental conditions in the case of the gypsy moth. In quite a number of forms, protandrous (Gk. *protos*=first; *aner*=male) or protogynous (Gk. *protos*=first; *gyne*=woman) hermaphroditism is the rule, it being usual for an individual first to function as a female or male, and then, later, as a male or female.

Manifestly, sex-reversal cannot be complete unless the component structures of the sex-equipment of the individual are capable of becoming transformed or else replaced. The ovary must be replaced or transformed

into a testis, or vice versa. The accessory sexual apparatus, the external organs of reproduction and the rest of the sex-distinguishing characters, must be capable of being either replaced or remodelled. It follows, therefore, that sex-reversal cannot occur in any mature individual whose sex organs are fashioned early in life and which thereafter lose all plasticity and become insensitive to any stimulus which, had it been exerted during development, would have guided their differentiation. No more can it occur in any form in which the differences between male and female architecture are based upon the differential development of two different sets of structures, one of which in either sex undergoes, early in life, complete atrophy.

One would not expect, therefore, to find complete sex-reversal occurring in the mammal after birth. It is possible that it does occur in the case of the bird. The evidence which exists is not conclusive, but certainly is highly suggestive. If one removes the functional ovary of a hen, commonly the right sex-gland, which normally does not develop, springs into activity and develops into an organ which, in its microscopical structure, is somewhat like a testis. In the great majority of such cases, however, spermatozoa are not found in this organ; but very exceptionally their presence therein has been recorded. Ovarian disease is relatively common among those varieties of domestic fowl which have been selected for high egg yield. A hen with an excellent record of laying ceases to produce eggs; her comb becomes as large and as erect as that of the cock of the breed; and she begins to crow. If one makes a post-mortem examination of such a case one finds that in the place of the ovary there is a large vascular tumour (*i.e.* a tumour very rich in blood-vessels). In other cases, the plumage becomes entirely cocky in structure and colour and in these cases one finds usually that the left ovary has become entirely atrophied, whilst on the right side there is a small sex-gland having the microscopical structure of a rudimentary testis. There are several instances of what would seem to be complete sex reversal in the fowl, in which a hen, which previously has been an excellent layer, rapidly assumes the male characters and actually fertilises the eggs of another hen. There must always be a doubt concerning such cases, however, for the reason that though one has no cause to question the statements of the breeder, it is from him that the professional biologist receives his material; so that the latter cannot personally vouch for the accuracy of the statements relating to the earlier part of the life history of the specimen.

If complete sex-reversal does occur, then it follows that it is due to the removal of the functional ovary by disease and to the consequent development of new sex-gland tissue, which assumes the structure of testes. One could easily explain the occurrence of sex-reversal in the fowl by an appeal to the hypothesis developed by Goldschmidt. If one assumes that during embryonic life the female-determining reactions are effectively in excess in the case of the female fowl, then the sex-gland will be differentiated under the influence of these reactions. The ovary develops and soon comes to consist of something like 3,000 immature eggs. Ordinarily, during the succeeding years of the individual's life these eggs ripen, and yolk is laid down. So long as this ovary remains healthy, then its action will preclude the operation of the male-differentiating reactions which, after embryonic

life, have been increasing in efficiency; but if the ovary is removed by the knife or by disease, then, should any further differentiation of sex-gland tissue occur, it will take place under the influence of these male-differentiating reactions which have overtaken and replaced the female-determining reactions.

That the soma can, and does, react to both the male and the female sex-hormone is shown in the clearest way by the case of the free-martin in cattle. The free-martin is a genetic female (XX in sex-chromosome constitution), whose reproductive system becomes abnormal during the period of the differentiation of the sex-equipment, as a result of the action of the male sex-hormone of a normal male co-twin. Twins in cattle may consist of two normal males, two normal females, one male and one female, each normal (this combination is exceptionally rare) or one male and a free-martin. Lillie, of Chicago, who finally solved this intriguing problem of the nature of the free-martin, found that the great majority of twins in cattle are fraternal twins and not identical. The two fertilised ova pass into the uterus and become attached to its lining. As the zygotes increase in size, their embryonic membranes meet and in the great majority of cases fuse; so that if the after-births are examined, when the calves are born, it is a matter of the greatest difficulty to separate one set from the other. If such fusion occurs, it is possible for the blood-vessels of each to ramify into the substance of the other, so that a common vascular intercommunication may become established. It was noted that when the twins consisted of one normal male and one normal female, there was no such vascular interconnection. If the twins are bisexual—that is, if one is a male and the other is a female—and if this fusion of the embryonic membranes occurs, and if the blood-vessels in them become conjoined, any sex-hormone elaborated by one individual can pass into the body of the other. If then, the testis of the male should become functional at an earlier stage in development than does the ovary of the female, the male sex-hormone will be elaborated and will be pervading the tissues of both fœtuses before the female sex-hormone is present. Under these circumstances, the female co-twin will pursue her development under the direction of the male sex-hormone elaborated by the testes of her brother.

Examination of the free-martin has shown that the assumption of the male characters by the female twin is imperfect. The external reproductive organs are of the female pattern, whilst the internal organs of reproduction are more or less completely male. The sex-glands, which normally would have become ovaries, assume the structure of imperfect testes. The degree of development of the mammary glands of the free-martin is as that of the immature female.

As has been stated, it is suggested that the female becomes abnormal whilst the male remains normal because the male sex-hormone is liberated before the female sex-hormone is present. Of course, this is not the only possible explanation. It may well be that the development of the sex-equipment of the male proceeds undisturbed by any influence exerted by the female co-twin. Obviously, either the female does not exert any influence on the male, or else this influence is not strong enough to overcome the tendencies toward male development as aroused by the male sex-hormone. It would seem that the former alternative is the correct one,

for it has been found that the removal of the ovary during the early stages of development, for example in a one-day-old rat, does not in any way affect the progress of the normal differentiation of the sex-equipment of the female; whereas castration of the day-old male rat is followed by very profound modifications. It would seem that the ovary does not exert any appreciable influence upon the soma before the individual has attained a certain age, and that the sex-equipment of the female becomes developed because the impulse to this differentiation is innate in the soma of the embryo. In other words, the female type of sex-differentiation owes nothing to the female sex-hormone. This is not to say that when once that sex-equipment has been developed, it does not depend upon the female sex-hormone for its maintenance. In contrast with this, the male type of differentiation demands the presence of the male sex-hormone elaborated by the testis. A body without a sex-gland, or with an ovary, will develop the female sex-characters (in the case of the rat or mouse) : a body with a testis will develop the male sex-characters. From the experiments which permit these conclusions to be drawn, the fact emerges that the differentiation into a female is a function which every embryo can perform, so long as no male sex-hormone is present to impose upon the body a male type of differentiation. The female sex represents, in the early stages of its development, the neutral form—that is, the form which the soma assumes in the absence of the male sex-hormone. On the other hand, every embryo would become a male if it were exposed during its early development to the action of the male sex-hormone.

If this be so, it follows that in cases in which the male sex-hormone appeared in the body at a later stage of development than was usual, a form of intersexuality would result, and that the degree of this intersexuality, as measured by the amount of femaleness in characterisation, would be an indication of the extent of the delay—the later the effective production of male sex-hormone the more femaleness. It so happens that a great many cases of intersexuality, which would seem to be best explained by an appeal to such an hypothesis, have been recorded. They are common both in the case of man and of his domesticated animals. The typical history in these cases is that an individual regarded as a female during the earlier part of its life later assumes many of the characters of the male. In man, there are many cases known in which the individual, having been reared as a girl, and even having become a wife, later undergoes a strange sex-transformation. There are many cases in the goat in which an individual has won prizes as a female kid and later has developed the beard and the head and the smell of a male. When the external reproductive organs of these cases are examined, it is found that though in general they resemble those of a female, the erectile organ, which in the female is quite small and hidden by the lips of the vulva, is over-large, whilst in the groin can be felt a pair of tumour-like bodies which, when removed and examined, are found to have the structure of undescended testicles. When one examines the internal reproductive organs, one finds that in addition to a more or less well-developed uterus there are the seminal vesicles, prostrate gland and epididimes, glands which either act as store-chambers for the semen of the male or else add their own contributions to his ejaculate (*see Fig.* 9).

Fig. 9. A CASE OF INTERSEXUALITY IN THE PIG

B.	Urinary Bladder	both sexes
C.C.	Penis	male
C.U.	Body of Uterus	female
Ep.	Epididymis	male
P.	Prostate	male
S.C.	Spermatic Cord	male
S.V.	Seminal Vesicle	male
Ts.	Testis	male
U.H.	Uterine Horn	female
Ur.	Ureter	both sexes
V.	Vagina	female
V.D.	Vas Deferens	male

The animal's reproductive system consisted of an intimate mixture of male and female structures, but the sex-glands themselves were found to be testes.

In order to understand these cases, it is necessary to understand a little about the origin and development of the reproductive organs. In the young fœtus, before the sex-characters are developed, there are to be found two minute rudimentary sex-glands, or gonads, which possess neither the characters of the ovary nor of the testis. The accessory sexual apparatus consists of two pairs of ducts, one of which is called the Müllerian, the other the Wolffian. The external reproductive organs consist of a cleft with a tubercle, the urogenital cleft and the genital tubercle. In that individual which becomes a functional male, the gonads become testes, the Wolffian ducts become the ducts of the testes which convey the spermatozoa therefrom to the penis, and the seminal vesicles and prostate. The Müllerian ducts atrophy, whilst the urogenital cleft and genital tubercle become the scrotum and penis respectively. In the case of the female the gonads become ovaries, the Müllerian ducts become the uterine tubes and the uterus, the Wolffian ducts atrophy, whilst the urogenital cleft and genital tubercle become the vulvo-vagina and clitoris. At the time of the attainment of sexual maturity, in the case of man between fourteen and twenty-one years of age, many other sex-dimorphic characters make their appearance; *e.g.* differences in the degree of development of the mammary glands, in the distribution of the hair, in depth of voice and so on.

Now, in these abnormal cases it is found that the gonads have become testes, that derivatives of both the Müllerian and Wolffian ducts become well developed, that there is some degree of abnormality in the development of the derivatives of the urogenital cleft and genital tubercle, and that those sex-dimorphic characters which are assumed later in life are of the male type. These abnormalities can be explained, if it is assumed that these individuals are males in their beginnings and that, owing to a delayed differentiation of their testes, the male sex-hormone did not come into play and control the differentiation of the Wolffian and Müllerian ducts and of the urogenital cleft and tubercle. Before the male sex-hormone was present differentiation would be that of the neutral type, that is of the female. After it had come into play the differentiation would be as that appropriate to the male. If there is a time seriation of events in the sex-differentiation of these forms, then the degree of abnormality will be determined by the time at which the male sex-hormone becomes operative.

If this is so, then it can easily be understood how it is that an individual, which is regarded as a female during the earlier part of its life, comes to assume male characters after sexual maturity has been passed. The sex of an infant, or of a kid, is identified by reference to its external reproductive organs. In the absence of the male sex-hormone, as has been said, the urogenital cleft and genital tubercle develop to assume a form which is indistinguishable from the normal differentiated vulvo-vagina and clitoris of the female. At the time of birth the genital tubercle is not overlarge; its size increases as the individual grows. The child is therefore regarded as a girl and is brought up as one. It is unlikely that any reason will present itself for examining further the external reproductive organs of such a child. At the time of, and after, sexual maturity the superficial sex-dimorphic characters become expressed, and at this time, if an

examination were made, suspicions would quickly be aroused. It would be found, for example, that the distribution of the hair on the body and the size of the clitoris were not in accord with the typical female plan, but such examination is not made until, as usually happens, persistent pain in the groin, together with the growth of hair on the face, sends the individual to a doctor.

In other cases of this kind a further abnormality is noted. The sex-glands, instead of consisting solely of testicular tissue, take the form of ovo-testes, which include both ovarian and testicular material. These are cases of what is commonly known as "glandular hermaphroditism" (*see Fig.* 10). Usually the testicular material contains no spermatozoa, but an abundance of that tissue which is known to be the source of the male sex-hormone. It is an interesting fact that the testis cannot elaborate spermatozoa if it is retained within the abdominal cavity. The reason for this would seem to be that the temperature within the abdomen, being several degrees Centigrade higher than that within the scrotum, is too high for the processes of spermatogenesis to proceed normally. In order to explain these cases, it is necessary to call upon the hypothesis adumbrated by Goldschmidt to account for his cases of intersexuality in the gypsy moth. These would seem to be individuals in whom there is a disharmony between the male- and female-determining factors in the hereditary constitution. If, for example, during the time of the differentiation of the gonad, first the female-differentiating reactions are effectively in excess, and if almost immediately these are supplanted and replaced by the male-differentiating reactions, then the gonads will become an intimate mixture of ovarian and testicular tissues. If the elaboration of the male sex-hormone on the part of the testicular tissue is somewhat delayed, there will result an intersexual condition of the accessory sexual apparatus and external reproductive organs, and when the development of the derivatives of the Müllerian and Wolffian ducts has been completed, the differentiation of these structures will be maintained by the male sex-hormone and by the female sex-hormone provided by the mixed sex-glands. Furthermore, the remaining sex-distinguishing characters, which depend for their expression and maintenance upon the sex-glands, will be developed under the influence of both ovary and testis and thus a sex mosaic, an individual with the characters of both sexes, will be produced.

THE PSYCHOLOGICAL ASPECTS OF SEX

The older psychology either disregarded sex altogether or, where it dealt with it, tried to bring it into line with the usual classification of the emotions. In recent years the scientific study of sex-behaviour has been undertaken, and into this particular problem the conception of the reflex mechanism has been introduced. These reflexes are mechanisms which play a very important rôle in a great many of the functions of the living organism. An example which one may display for oneself is that which is known as the knee-jerk. By sitting with one leg resting upon the other, with both knees bent and the muscles relaxed, and by striking with the edge of the hand just below the knee-cap of the upper leg, one will notice that this leg gives a sudden kick. Consciousness is not involved in this

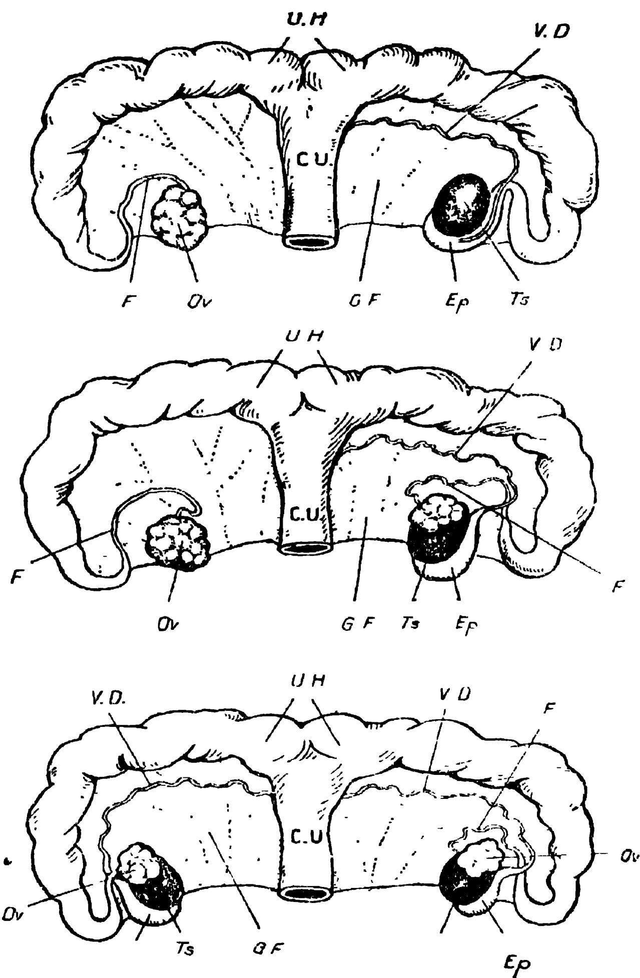


Fig. 10. DIFFERENT TYPES OF "GLANDULAR HERMAPHRODITISM" ENCOUNTERED IN A PIG

C.U. Body of Uterus
Ep. Epididymis
F. Fallopian Tube
Ov. Ovary
Ts. Testis
U.H. Uterine Horn
V.D. Vas Deferens

action. What really happens in this series of events is that the sudden blow to the tendon of the knee-cap involves the stimulation of the sensory nerves therein. Along these the message is passed to the spinal cord, where it is, so to speak, switched-over to associated motor nerves, along which passes the complementary message which provokes contractions in certain muscles of the leg. Now, the essential feature of this so-called reflex arc and its functioning is its entire independence of consciousness and deliberation. Many are the reflex actions of this kind, and without doubt they are of the greatest importance to the organism. The blinking of the eyelid if a speck of dust or any other foreign body touches or threatens to touch the eyeball, the coughing that follows immediately upon the irritation of the back of the throat, the sudden withdrawal of the hand when it touches unexpectedly something hot or very cold, the leap for safety out of the way of the on-rushing motor-car—these are all instances of reflex actions, which may be so important to the individual as to make all the difference between living and dying.

In the case of insects, behaviour can be simply and generally explained as a complex of reflexes which are predetermined in the structure and in the organisation of the animal. For example, there are caterpillars which invariably, when moving, crawl in Indian file, one behind the other; the first one being directed in its movements by certain conditions of the surface of the body on which it seeks its food. All the rest follow strictly in the train of the first. Should one force the first caterpillar to cross its own trail, then it will follow that trail and the whole procession will move continuously in a circle, even though in doing so they can never reach their object and inevitably must starve. Practically every kind of behaviour in the insect can be explained by reference to some reflex action. It flies toward a flower, not because it wants to do so, but because it must. The flower excites certain sensory nerve-endings, and these in their turn incite the movements of those muscles which, in their action, direct the animal toward the flower.

It might seem at first sight that in this matter of reflex action one cannot compare an insect with the higher mammals, but it can be shown in the case of those animals which are available for experiment, and which must be regarded as being essentially similar to man in respect of their behaviour, that reflex actions such as exist in the insect also operate in them. For example, appropriate stimulation of the male ejaculatory organ, or of the female genital region, produces a state of general sexual excitement which can lead to the climax of the sexual act, ejaculation in the case of the male and contraction of the uterus during an orgasm in the female. The chain of these reflexes has been investigated, and it is now known that the stimulus applied to the genital region provokes a nervous reaction which is conducted to the lower part of the spinal cord, where it links up with motor centres, and that nervous stimuli sent therefrom lead to the contraction of the muscles surrounding the deferent duct of the testis, thus producing ejaculation in the case of the male and, in the female, to a contraction of the muscles of the uterus. In the case of the guinea-pig boar, if one places an electrode to the tongue and another to the skin of the neck and then releases a slight electric shock, the animal will behave exactly as it does during the act of sexual congress, there

being erection of the penis and complete ejaculation, although no female and none of those stimuli which normally call forth sexual excitement are present. The explanation for this behaviour is that the electric current directly excites the motor centres in the spine which normally are stimulated by messages received by way of the sensory arms of this reflex arc, and this leads to exactly the same effect as does the presence of a female in heat. It has also been shown experimentally, that even after removal of those portions of the brain which are known to be concerned with the higher psychical functions, this electrical stimulation produces exactly the same result. It follows therefore that erection and ejaculation in the male and contraction of the uterus in the female, phenomena which are the most prominent features in the act of sexual congress, are reflex actions and are not under the control of the brain.

The reflex nature of the sex act has been demonstrated in the clearest possible fashion in certain of the lower forms of life, for example, the garden snail. It has already been mentioned that the sexual organisation of the snail is complicated. There is only one kind of individual, each has both ovarian and testicular tissue and each produces both ova and spermatozoa. Nevertheless, two individuals mate and during this process they exhibit very intricate movements and seem to express very considerable excitement. Yet one can show, in the simplest fashion, that the whole chain of events is dominated by simple reflexes. If one should stimulate certain regions of the body surface in an orderly sequence, one can produce in a single snail, in the entire absence of any other individual, all the expressions of the sex act in exactly the same sequence as these occur during normal mating. It is a long way from snail to man, and certainly in all forms it is not so simple a matter to demonstrate the chain of reflexes and complexes which constitute the complete performance of the sex act. But there is no doubt that whilst stimuli which are not of a tactile, olfactory or visual nature have yet to be investigated, it should be possible in the future to interpret the whole sexual behaviour exhibited by the higher forms as a series of reflex actions.

So far, only the act of sexual congress itself has been discussed, but observations have been made which show quite clearly that sex-behaviour, in the wider sense of the word, is no less reflex in nature than is the actual sex act itself. In the rat, for example, one notes that sexual behaviour in the case of the female is restricted to certain periods—the periods of œstrus (Gk. *oistros=gadfly*) or heat—which recur following intervals of four to six days. The male, on the other hand, is always prepared to exhibit sexual activity. There are two entirely different kinds of response on the part of the female to the advances of the male, according to whether or not she is in heat. If she is not, then she replies to the approach of the male with very definite movements of defence, making copulation impossible for mechanical reasons. She simply will not receive the male. But later, when she comes in heat, this behaviour changes completely, and on the approach of the male she crouches, arches her back and thus makes sexual intercourse possible. But a female rat which is in heat will not only crouch on the approach of a male, but can be induced to do so in response to very different kinds of stimulus. If, with one's fingers, one should press upon her back, she will adopt the mating position. Thus it

appears that we are dealing with another example of a reflex action, one which does not occur at any time but only during the heat period. It may be said that the main feature of œstrus, or heat, is that during this period the mating reflex can be exhibited by the female. It matters not by what the stimulus is exerted : it may be a male or it may be the pressure of the human finger. During this time, if this particular stimulus is exhibited, the response is inevitable and is not under the control of the will of the rat.

In the case of the male, whilst there is no reason to assume that a similar kind of mechanism is not involved, it is probable that the mechanism is rather more complicated. It would appear at first sight that the stimulus which releases sexual desire in the male is the smell, or the sight, of the female. However, males which are blind, which have been robbed of their sense of smell, whose cutaneous sensations have all been obliterated, and which are deaf, nevertheless can perform the sex act as readily and as efficiently as does the normal male. It follows, therefore, that it cannot be the smell, or the sight, or the noise made by the female which evokes the exhibition of sex behaviour on the part of the male. One has to conclude from all the observations which are available, that there is automatism in the male which leads to a continual urge to perform the sex act. The actual performance of the male during sexual congress is nevertheless conditioned by the behaviour of the female, and ejaculation does not take place until the female has permitted the male to mount her. So it would seem that the male endures a continual urge to pursue and mount the female, and that as soon as the latter permits him to do so ejaculation occurs as a reflex act. If this be so, we are dealing with a chain of reflexes which, in their functioning, are conditioned by the occurrence of reflexes in another individual. Manifestly, such mechanisms may be very complicated. If they exist in the case of man—and there is no reason to assume that they do not—then in all probability the sensory stimuli must be largely presented by the physical attractions of the heterosexual partner ; these, in their turn, being qualified by all sorts of inhibitions and preferences born of social experience. However, the application of the concept of the reflex arc to the problems of sex-behaviour has placed future research in this particular field on a firm basis. This has made it possible to exclude the influence of consciousness as an active factor in matters of sex, and to regard consciousness as a more or less additional phenomenon.

The study of reflex mechanisms in relation to sex-behaviour leads inevitably to a consideration of the nature of the attraction that one individual can exert for another. It is the rule that it is the male of the species which exhibits the desire to mate, which pursues the female. But this is not essentially a male characteristic, and it can be shown that it is not the presence of the testis which determines this form of activity. There are species in which the male is inactive and in which the female plays an active rôle in courtship. Among birds, for example, in the case of the Phalarope it is the female which wears the brighter plumage and plays the active rôle in courtship, though amongst breeds generally the adornment of the male far surpasses that of the female, and it is the male which is prone to exhibitionism. But these exceptions to the rule show clearly that

sex-behaviour is by no means necessarily related to the production of spermatozoa or ova, and that the psychological sexuality of an animal may be quite different from physical sexuality. This fact has given rise to considerable speculation, and has encouraged certain experimentation relating to the condition of homosexuality in man.

Homosexuality has been regarded as the state in which an individual, equipped with all the physical characters appropriate to one sex, exhibits the psychological characters appropriate to the opposite sex. Thus a homosexual male was looked upon as being psychologically female, though structurally male. It was but natural that against the background of our knowledge of the relation of the endocrine glands and the sex characters, it should be assumed that this homosexuality was to be attributed to the secretion on the part of the gonad of the wrong sex-hormone; that is to say, that a testis, instead of elaborating male sex-hormone, was producing female sex-hormone, and vice versa. Steinach concluded from his studies that the male homosexual had an abnormal testis of this kind, and argued that the cure of homosexuality must take the form of the replacement of the testes of the patient by others from a normal heterosexual male. Clinical records seem to show that in this way homosexuality could indeed be cured; but there is reason to think that this experimentation and its clinical application were erroneous, both in conception and in the recorded results. It is well known that the human subject is a very unsatisfactory experimental material. The patient himself rather complicates the experiment by allowing opinion and self-interest to colour his symptoms, and his examination can never be sufficiently objective. Moreover, it is commonly forgotten that there is no real reason why the homosexual should be essentially different from the heterosexual. It is well known that the male of domesticated animals, under certain conditions, very frequently attempts to perform the act of sexual congress with other males. If twelve cocks are kept together, in the absence of females, it is certain that some of these males will be treated by the rest as though they were females. Homosexuality does not consist so much in differences in male behaviour as in the choice of unusual objects. If the appropriate object is absent, or if the individual is unable to identify the proper sex of the object, then copulation will be attempted, but it will be successful only if the partner is the female. It would seem, therefore, that homosexuality is not so much due to a disturbance in the secretions of the endocrine (Gk. *endon*=within; *krinein*=to separate) glands, but rather to a disturbance of the central nervous system which results in the choice of an unusual object for the purposes of mating.

At this stage we must return once more to the sex-hormones. Thus far we have discussed the influence of these upon the structural and physiological characters of the individual, but it can be shown that their influence upon the psychical characters, as expressed in sex-behaviour, is no less pronounced. The female rat from which the ovaries have been removed no longer shows that periodic recurrence of heat which is typical in the case of the normal rat. In respect of sexual behaviour she is indeed asexual. For her life is but one long " interval," no mating is ever observed. On the other hand, should one inject the female sex-hormone which leads once again to the development of the genital organs, one finds

that the injected female again exhibits sexual behaviour. The animal which has received a sufficient quantity of extracts containing female sex-hormone behaves exactly as does the normal female rat during the period of œstrus. It responds to the approach of the male with the typical mating reflex. It is obvious, therefore, that the sex-hormone erotinises the nervous system and this creates what one might call the psychological condition of sexual activity. As yet we have no knowledge as to the method by which this state of erotinisation is actually produced, nor of the changes in the nervous system created by the hormone. Nevertheless, it can even now be stated that the mechanism which is concerned with sex-behaviour has been disclosed, and that the exhibition of this mysterious urge, concerning which mankind has speculated for centuries, can be called into being by the administration of a substance, chemical in nature, the actual composition of which will soon be known.

In the case of a male the facts are somewhat different. If one removes the ovary from a female rat, sexual activity is immediately obliterated. In the male, on the other hand, this only occurs if castration is performed before the individual has reached sexual maturity. This is not true only for the rat, for it applies also to man. It has frequently been described how men who have been castrated before they have reached puberty have never developed the sex-characters of the male, but that if castration occurs in adult life, sex-characters and sex-behaviour are not thereby completely destroyed. It follows, therefore, that the erotinisation of the nervous system which occurs at the time of puberty persists in the case of the male for a longer period of time than it does in the case of the female. But it can be shown that this again is due to the action of a sex-hormone, in this case, the male sex-hormone, which, as has been shown, is responsible for the expression and maintenance of the physical sex-characters of the male. If one castrates a guinea-pig the seminal vesicles, which provide the bulk of the fluid in the ejaculate, atrophy, and though erection may still occur, ejaculation is impossible, since there are no spermatozoa and no secretion from the seminal vesicles. After a time the power of erection of the penis also disappears and the sex-urge becomes greatly diminished. However, injection of the male sex-hormone restores this sex-behaviour and the power of erection, and should one now apply the electrical stimulus to which reference has already been made one notes that the guinea-pig responds with a complete ejaculation.

The psychological effects of these sex-hormones are not restricted to the field of sexual activity as ordinarily understood. Rats that are kept for laboratory purposes are provided with revolving cages, in which they take their exercise. It is to be noted that the rat is a very active animal, and that if a contraption like a cyclometer of the ordinary push-bicycle is attached to the revolving drum, they spend hours in this drum and travel for miles at a time. It has been found that this spontaneous activity of the rat is an indication of the individual's sexual activity. For example, in the case of the female, the animal about to come in heat takes far more exercise than she does in the interval between two heat periods. After ovariectomy there is a remarkable diminution in the amount of this spontaneous activity, but should such an ovariectomised female be injected with the female sex-hormone, then her spontaneous activity is

raised again to the normal level or even beyond it. The same is true of the male. If we tried to translate these findings into ordinary language, we might be inclined to say that the animal which exhibited a high degree of spontaneous activity was a very energetic animal, and the animal with a low spontaneous activity a relatively lazy animal. It is an interesting thought that the degree of this activity is related to the intensity of the sexual urge. The tendency to go hiking, to indulge in Rugby football, or violent games of tennis, the running round and round in a revolving cage, these all would seem to be of the same order, and laziness and activity would seem to represent the reaction on the part of the nervous system to those chemical agencies, the sex-hormones.

It is necessary to make an attempt to link up these facts and suggestions with certain of the statements of modern psychology, particularly of psycho-analysis. The psycho-analytical point of view is that the primary source of mental energy is represented by the sex-urge, which can be directed to other purposes during the course of individual development and ordinarily is so transferred.[1] It must be the purpose of future investigation and of theoretical analysis to examine the possibility of interpreting physiological findings such as have been discussed in psychological terms, but attention should now be drawn to the fact that in the case of the experimental animal, at least, the sex-hormone is the creator of sexual energy in the strict sense of the word as well as of general activity and that, in addition, these hormones are intimately concerned with the expression of the higher functions of the nervous system.

The maze is a favourite instrument of the experimental psychologist. Rats have mostly been used for these experiments, and the task set them is to find their way to an inner chamber where food is offered. The number of trials and errors until the individual passes directly and without hesitation to the food is registered as the measure of the learning ability of the rat. It has been found that the supply of sex-hormone is a factor of great importance in the degree of learning ability exhibited by any particular rat. The female sex-hormone increases the ability to learn when it is given in certain concentrations, whereas the absence of the female sex-hormone decreases the ability to learn just as it decreases the amount of spontaneous muscular activity. It is not extravagant, therefore, to suggest that future developments in this field of research will lead to most far-reaching consequences, inasmuch as mental development seems to be so very dependent upon the proper supply of the sex-hormones. It follows that if this is so, then when these hormones are available in pure and simple form it should become possible to control the development of the mind through their use to an extent far beyond that which is at present imagined by the orthodox psychologist, who, after all, deals only with the product of the reaction and not with the reaction itself.

It is profitable to approach this subject from the opposite angle, and to enquire how far sexual activity and the act of coitus affect the glands of internal secretion. This system of glands, which includes the thyroid, pituitary, adrenal, ovary and testis, consists of organs which elaborate specific products of a chemical nature, hormones, which pass by the

[1] For a fuller treatment of this subject, see the Article on *Psycho-Analysis*, p. 373.

blood stream throughout the body. There can be no doubt that, in some form or other, these ductless glands are influenced in their functioning by the expression of sexuality. As yet but little is known of this subject, but an inkling of the facts may be gleaned from a consideration of the relation which undoubtedly exists between sexual activity and the functioning of the pituitary, a small gland which lies at the base of the brain.

Medical men have known for a long time that certain types of disease and degeneration of the pituitary are accompanied by an imperfect development of the reproductive organs—there is a diseased state known as pituitary infantilism. Extirpation of the pituitary in an otherwise normal individual leads to atrophy of the testes, and therefore to an atrophy of those sex-characters which depend for their maintenance on the supply of the male sex-hormone. Furthermore, implantation of the anterior lobe of the pituitary in such animals leads to the repair of the testes, and therefore to a re-development of those sex-characters which are dependent upon the gonad. The same is true of the female. Furthermore, if one implants small pieces of the anterior lobe of the pituitary or injects prepared extracts of this lobe into sexually immature animals which normally would not reach puberty for a considerable time, one finds that almost immediately the changes characteristic of puberty appear. Thus it is that young mice, being so treated, come rapidly into heat and their ovaries show mature ova, whilst the testes of young males similarly treated pursue a greatly hastened development. Male sex-hormone is elaborated, and this incites a rapid development of the penis and of the other male sex characters.

It is seen from this and similar experiments that the function of the gonad, which controls the development of the sexual characters, is not an automatic one, for it depends upon the presence and action of a hormone elaborated by the anterior lobe of the pituitary. It follows, therefore, that the anterior lobe of the pituitary is as much the spring of sexual activity as are the gonads, even if not more so. But it must be recognised that the sex-differences exhibited by male and female cannot be due to the action of the pituitary itself, for this gland secretes the same hormone in the male as it does in the female, and the differences are due to the fact that in the male the pituitary hormone activates the testis whilst in the female it activates the ovary.

The intimate interrelation between pituitary and ovary can be illustrated by reference to the state of pregnancy. It has been shown that in addition to the female sex-hormone which is elaborated by the ovary, and is responsible for the expression of the physical and mental characters, which in their combination constitute œstrus, or heat, another hormone is secreted by the ovary. It is known that after mating the uterus of the mouse and the rat undergoes certain changes which make pregnancy possible. Its lining membranes become thickened to form a bed, in which the fertilised egg may become implanted, and later to take part in the formation of the placenta, or after-birth. Now, these changes in the uterus occur under the influence of an ovarian hormone, probably elaborated by the corpus luteum, that is very different in its nature from the female sex-hormone. (The corpus luteum, or yellow body, consists of glandular tissue, yellow in colour, which develops in the scar on the

surface of the ovary after the rupture of the ovarian follicle and the escape therefrom of the ovum.) Therefore, the ovary, through these two hormones, controls not only sexual activity but also reproductive activity. In the rat, for example, the secretion of this second, pregnancy-promoting hormone does not begin until immediately after mating : that is to say, the preparation of the uterus for the reception of the fertilised egg by means of the action of this second hormone does not begin until immediately after insemination and fertilisation. The sex act itself brings about a very definite change in the hormone function of the ovary, and this in its turn leads to the development of markedly changed conditions in the psysiological and psychological state of the individual.

Now, these changes can be brought about artificially. A rat will exhibit all the features of pregnancy if, during the period of heat, the neck of the uterus is stimulated by means of a fine glass rod. One must assume, therefore, that mating leads to the stimulation of certain nerve endings in the neck of the uterus and that along these sensory nerves are passed messages which ultimately affect the functioning of the anterior lobe of the pituitary, which then proceeds to produce a second hormone and this affects the ovary, calling forth the second ovarian hormone which, acting upon the genital tract, stimulates this to develop the conditions of pregnancy.

This account may serve to illustrate the very intimate interrelationship that exists between the various members of the system of endocrine glands, and how several of them are not only directly concerned in the expression of the physical and physiological characters that pertain to sex, but also how they would seem to lie at the basis of much that is at present claimed as the peculiar possession of the psychologist. It may be expected that further investigation will show that quite commonly there is an understandable physical basis for that which one is wont to call a purely emotional phenomenon.

THE SEX-RATIO

The sex-determining, sex-chromosome-distributing mechanism should lead to the production, in the case of a bisexual species, of equal numbers of males and females in each new generation, for the reason that the two forms of gametes elaborated by the digametic sex should be produced in equal numbers. The primary sex-ratio—that which obtains at the time of conception—should therefore be equality. There should be 100 males per 100 females conceived. If this primary sex-ratio is not equality, then we must conclude that either the two forms of gametes are not produced in equal numbers or else that one is more successful in the act of fertilisation than is the other. Observations that have been made demand for their explanation that certain individuals do indeed produce more of one kind than of another, and experiment has shown that it is possible to influence the proportion of the two kinds produced.

Thury, in 1863, developed the theory that an ovum fertilised soon after extrusion from the ovary tends to produce a female, whilst an older ovum will later develop into a male. This theory has been incorporated into the practices of breeders of domesticated animals, and indeed statistical

investigations undertaken by Pearl and his colleagues in America seemed to show that possibly the theory was correct. They found that, in the case of cattle, the sex-ratio amongst calves which had been conceived during the earlier part of the period of heat of the mother was significantly different from that of calves conceived during later periods. However, further figures collected by the same investigators showed that this conclusion was not tenable. But that over-ripeness of the egg, such as might result from delay in fertilisation, is associated with a swing in the sex-ratio is shown by the work of Hertwig and his pupils. The female frog only lays her eggs whilst the male is on her back, exhibiting the mating reflex. A male frog was allowed to fertilise half the eggs extruded by a female and was then removed, and after varying intervals of time was replaced and allowed to fertilise the remaining half. It was found that with increasing intervals more and more males appeared amongst the offspring, so that after an interval of 89 hours between the fertilisation of the first and the second half, none but males were produced. It was shown that this was not due to any sexually selective mortality, and that the only explanation that can be given is that the over-ripe egg when fertilised inevitably becomes a male, whether it is fertilised by an X-chromosome-bearing sperm or by a Y-chromosome-bearing sperm.

If the primary sex-ratio were equality, but if a sexually selective pre-natal mortality operated, then the secondary sex-ratio—that which obtains at the time of birth, or hatching—would be more or less removed from equality according to the intensity of this pre-natal mortality. In the case of man it is known that more boys than girls are born: the secondary sex-ratio for Great Britain being roughly about 103 : 100. Thereafter, in every age-group save those which include the onset of menstruation and of the climacteric in the female, the death-rate is higher amongst the males; so that amongst the people in Great Britain who are 80 years old or older there are about 2 women for every man; that is to say, that during post-natal life there is sexually selective mortality operating which reduces the sex-ratio at birth of 103 : 100 to one of 50 : 100 amongst the age-group 80 or over.

It will be found on examination that the sex-ratio amongst still-births—that is, amongst infants born dead at or about full-term—is distinctly higher than that amongst children born alive. This means that still-birth is more common amongst boys than girls. The sex-ratio amongst abortions—that is, amongst fœtuses born dead between the time of conception and the seventh month of pregnancy—is again higher than the sex-ratio of still-births. It is impossible to identify the sex of the fœtus before the third month of pregnancy, but such figures as are available seem to show that the sex-ratio is highest amongst abortuses of the third and fourth month, and that thereafter it declines in a steady fashion to blend with the secondary sex-ratio of 103 : 100.

It follows, therefore, that, in the case of man, a sexually selective mortality is operating both before and after birth. It also follows that if the secondary sex-ratio is 103 : 100, in all probability the primary sex-ratio is not less than 150 : 100. Far more boys than girls are conceived, but far more boys than girls die before they are born. It is difficult to offer any adequate reason to explain this fact. All that can be suggested is that

whilst sex-linked recessive characters, that are lethal or semi-lethal in their effects, could account for some of the mortality amongst the males, it is impossible to call upon these agencies to explain the whole. All that can be said at the present time is that the male would seem to be less able to withstand unfavourable conditions. It is certainly true that amongst those peoples who take parentage seriously (the Jews, for example) the secondary sex-ratio is higher than that of other sections of the same community. It is probable that the present developments in ante-natal and child-welfare practices will lead to the raising of the secondary sex-ratio.

CONCLUSION

A survey of the facts and of the fancies that have been presented enables us to express certain reasonable expectations. The problem of the control of sex-determination and of sex-differentiation is one that intrigues many minds. According to many the problem has already been solved. Almost every year there appears a book or a pamphlet written by someone—never a professional biologist—who claims to have found the key to this particular riddle. More commonly than not they have rediscovered that which Rumley Dawson thought he had discovered, and the theory, which underlies the practices which they advocate, demands that in the case of man and his domesticated animals the female and not the male shall be the digametic sex. The usual form of the theory is that the two ovaries differ one from the other in that one produces eggs which, being fertilised, are destined to become males, the other producing eggs which are destined to become females; and that the ovaries function alternately with succeeding heat or menstrual periods. If, then, one notes the sex of the first offspring and is able to relate the conception associated with the pregnancy that produced this to a particular menstrual period or period of heat, one is thus enabled to predict the sex of any subsequent offspring.

Another variant of this theme is that the ovaries, one being male-producing and the other female-producing, function synchronously and that the sex of the offspring is determined by the direction of the flow of the male ejaculate. Thus is it that breeders have their cows served on the slope of a hill, one flank being lower than the other. The semen of the male is supposed to drain toward the lower flank and therefore ensure fertilisation of an ovum elaborated by the ovary on this side.

There is no doubt that statistics can be collected which completely prove the correctness of these theories, or, on the other hand, disprove them. In any case, any discrepancy can most easily be explained by reference to faulty observation or to a temporary abnormal functioning on the part of the two ovaries. The fact remains, however, that these theories, attractive as they are, cannot be brought into line with established scientific fact. Biology has shown that it is not the female of the mammal but the male that is digametic, and that the problem of the control of the sex of the individual that is to be will only be solved when it has been found possible to ensure that fertilisation is affected by one or other kind of sperm. It is possible that the two kinds of sperm might be separated if they were forced to travel through an artificially produced chemical field

in the vagina of the female, one kind being more or less completely immobilised. But so far no experimental application of a physical or chemical agent has succeeded in separating the two forms. If and when such separation is affected, then of course it should become eminently possible to ensure that the result of fertilisation shall be male or else female.

The future is full of promise, for with developments in our knowledge of the endocrine basis of sexuality it should quickly become possible to control the expressions of puberty and of senility, due to breakdowns in the hormone function of the sex-glands and of the pituitary. Since disharmonies in the functioning of these glands of internal secretion are responsible for so much personal and social misery, control such as is envisaged could prove of the greatest benefit to mankind.

PSYCHOLOGY

By

F. AVELING

SYNOPSIS

Rise of psychological problems in prehistoric speculation; animism — Gradual emergence of distinction between living creatures and inanimate beings; between life and mind — Position of psychology in Greek philosophy; soul and body, dualistic views (Plato, Aristotle) — Freedom and determinism — Importance of psychology in early Christian thought; emphasis upon the human soul, its nature, origin and destiny (Augustine) — Development of psycho-physiological and psychological doctrines in mediæval Scholastic philosophy; intellect and will (Aquinas, Scotus) — Renaissance and post-renaissance period — Theories of interaction between soul and body (Descartes); of parallelism; of monism; of panpsychism (Leibniz) — Beginnings of empirical psychology (Locke) — Laws of association and associationism (Hume) — Development of contemporary psychology under the influence of the theory of evolution (Darwin, Spencer) — Emotions and behaviour — Individual differences (Galton) — Comparative psychology; study of the behaviour of lower animals, primitive peoples and young children — Physiological psychology and experimental psychology (Wundt) — Social psychology (McDougall) — More important contemporary systems of psychology; Behaviourism; Psycho-analytic schools; "Gestalt" psychology; Noegenetic, or Two-factor, school; dynamic psychology and personalism — Applications of psychology to problems of life and living; education; medicine; industry and commerce, etc. — Definition of psychology.

PSYCHOLOGY

INTRODUCTION

Psychology is still a science in the making rather than a finally established one. This is indicated by the lack of agreement among psychologists upon the exact definition of the subject. There are a number of contemporary schools in existence, each advocating its own particular principles and methods and defining psychology in its own way. It is thus presented as the science of the soul, of mind, of consciousness, of behaviour, and the like. And this is not astonishing when we remember the extraordinarily varied interests of psychologists to-day. They cover so wide a range, and involve so great specialisation, that many points of view are inevitable. There is, however, more real unanimity than might appear on the surface; since, with negligible exceptions, all would agree that the principal subject-matter of psychology is human conduct; that it is concerned with conduct in order to discover the principles which account for it, and so be in a position to control and guide it; and that the methods to be employed in the study are the observation of behaviour, on the one hand, and introspection or the inner observation of our own conscious processes, on the other. All the definitions, though apparently exclusive, can be reduced to a single formula. Psychology is the science which investigates behaviour in general from the point of view of its mental implications, whether conscious or unconscious, with a view to control.

To appreciate the present state of scientific psychology it will be useful to review the outstanding points in its historical development. It is the last of the sciences to have broken away from philosophy; and it still raises acute philosophical problems at every turn. Solutions of these problems have been offered by a succession of great thinkers, in which we find a progressive clarification, each advance marking a higher achievement than the preceding one. But almost from the outset we discover indications of contemporary systems. The central problem, towards which all the others converge, is and always has been that of the nature of man as shown in his various activities, and particularly those of feeling, thinking and willing, so far as they account for human conduct. The history of psychology, accordingly, will be an account of the ways in which conduct has been interpreted, and of the different conceptions men have framed of themselves as actors in the drama of life. It could have no beginning until the observation that such conduct differs radically from the behaviour of inanimate beings, and in many essentials also from that of animate creatures other than human, had provoked reflection upon the reason why this should be so. From the very origin of the human race man has presumably been a self-conscious animal; but there could have been

no psychology, even the most rudimentary, until he came to reflect upon his own self-consciousness and attempt some explanation of it.

PREHISTORIC THOUGHT

It has been assumed that psychology originated in the thoughts of primitive men about the phenomena of sleep, dreams, insanity and death. These would lead to belief in the existence of impalpable counterparts of the bodies of the living, which were capable on occasion of severing their connection with the body, and at death finally departed from it to live on as ghosts in an underworld. Proof of this for the primitive mind would lie in the fact that the inert body of the sleeper awoke to report dream adventures in remote places and times, and to recount his meetings and transactions with people already dead. Further proof would be found in the phenomena of mental disease, which would point towards possession of the body of the sufferer by conscious agents other than himself, by demons, ghosts or forces able to control its actions even against his will. The conscious wraith, wandering abroad in sleep and disappearing at death, would be held to inhabit the body during life, and to account for the latter's vital actions, movements, feelings, thoughts and desires. The assumption presupposes considerable reflection already on the part of primitive man; and it is probable that it was preceded by a stage of development in which no distinction was made between animate and inanimate beings, but all were thought of as possessing hidden activities similar to those of man himself. In this stage, by an analogical interpretation of Nature in the light of the primitive's own experience, everything would be regarded as endowed with conscious life, and able to play its kindly or malevolent part in human affairs. Until this stage had been outgrown, and distinctions between conscious and unconscious beings recognised, there could be no beginning of science, either physical or psychological. There is evidence of a phase of animism (the endowing of physical objects with consciousness) which precedes the distinction of living from inanimate beings in the developing mind of the very young child which, according to the theory that the development of the individual recapitulates the evolution of its kind, represents the mind of the race in its childhood. We find such evidence also in the early speculations of philosophy. But from the point of transition onwards, psychological history is the history of the problem of the conscious self. No doubt a gap of centuries lies between the vaguely felt distinction and the earliest records of explicit attempts to explain the nature of the universe and of man as a part of the universe. Such systematic attempts, however, were made by the Greek philosophers. Beginning with them, accordingly, we may divide our summary into four main periods : (1) the epoch of Greek speculation, in which the Mind-Body dualism arises in a general framework of philosophical theory ; (2) the period of mediæval thought, during which great emphasis is laid upon the mental powers as indicating the spiritual nature of man ; (3) the modern era, beginning with the distinction drawn by Descartes between the body and the mind ; (4) contemporary psychology, dating back to the introduction into science of the hypothesis of evolution.

The central problem of psychology emerged only gradually in Greek speculative thought, and phases in its development may be distinguished. Greek philosophy arose in an atmosphere of strongly religious and mystical tradition, and at first was mainly concerned with the study of external Nature in a search for principles by which the latter might be explained. The early philosophers were extroverts, *i.e.*, their interests were centred upon cosmic changes rather than upon themselves; and they found the principles required in a physical element, or combination of elements, together with a life-principle not separated from these. All matter is alive, and all living things have souls. An advance was made, however, in the distinction of the forces of love and hatred (attraction and repulsion) from the original, imperishable elements, fire, air, earth and water; an interpretation of physical change, though not clearly recognised, on the lines of psychical experience. Dualism begins vaguely to assert itself in cosmology, or the philosophical interpretation of physical Nature. It also asserts itself psychologically in a theory of perception. Perceptions are due to emanations from bodies which pass through the pores of sense to the soul, in which like is known by like. Thought is ascribed to all things without distinction, and depends upon the mixture of the elements. A still more interesting advance was made when the formative power of mind or reason was postulated to account for the origin of the world from a primitive agglomeration of infinitely small particles of every sort of substance. A principle which cannot be perceived by the senses is for the first time invoked to explain the evolution of the cosmos; for mind is distinguished from material things by its characters of simplicity, freedom, omniscience and omnipotence. Just as hylozoism (the conception of the all-pervading life of matter) was a projection of unanalysed personal consciousness upon objects of the external world, so here spirit or reason, experienced in personal thinking, planning and willing, is a projection upon the universe. Thus cosmological dualism (world and soul) is the result of the beginning of reflective analysis of mental process. In psychology this indicates a clearer distinction between sensory and intellectual knowledge. The former, though not necessarily deceptive, is weak; the latter acquaints us with the truth, and is due to a spiritual principle or soul. Mind, accordingly, is not only a principle which accounts for the formation of the world, and implies teleology or progress towards a goal; but also in man it takes the form of an individual soul in a material body. Immanent in the universe, it is also an immanent constitutive principle of the individual person. This doctrine marks a distinct advance in an entirely new direction; but it was not consistently followed up, and gave place to a theory of atomism in which inherent necessity was substituted for mind or reason in explanation of the way in which cosmic processes came about by the aggregations of physical atoms. Yet psychological problems occupied attention even in this new phase of thought. A theory of knowledge was advanced in conformity with the atomistic postulate. Nothing save material atoms exists. Sense-perception, accordingly, is mechanically determined by images which emanate

from objects and come into contact with the soul. But such perception is obscure and deceptive; for it presents as qualities what is, in fact, quantity. Thought also is a mechanical modification of the soul; but in thought we grasp the true natures of things as constituted by the invisible quantified, material atoms. Impulse, conation (striving) and will are explained as the giving out again of the images received in perception. In this theory the distinction between soul and body is not rejected; but the soul, like all else, consists of atoms of " fire," perfectly smooth and round. It is the noblest part of man, warming his body while alive, and separated from it at death. Atomism reduces psychology to physics, but has significance in psychological history. By stressing the mechanical aspect of Nature, it made way for a vivid contrast between it and the subjective world of Mind; and by calling attention to the illusory nature of sensory knowledge it called for a critical examination of all knowledge by a subjective analysis. The antithesis between thought and perception came also to expression in other early schools of Greek thought. It was emphasised by the attempt to explain cosmic change on the basis of mathematical relations. Numerical concepts, unlike the changing objects of sense experience, are eternal, unchangeable, imperishable; and accordingly provide a higher kind of reality for thought than that reached in perception. Nature obeys the mathematical laws of abstract number; and to know Nature is to know the laws its phenomena express. Applied to psychology, this view makes the soul the numerical harmony of the body, just as the world-soul from which it derives is the harmony of the universe. Its parts, or faculties, are reason, understanding and desire. But this classification of powers is less important than the concept of the principle from which they derive as an abstract mathematical relation. This was a parallel of the still more abstract concept of Being, which was developed in another line of thought, and still further stressed the antithesis between sense and reason. A group of thinkers, beginning with the postulate that Being *is*, and not-Being can neither exist nor be conceived to exist, came to the conclusion that Being is one—unproduced, unchangeable and undivided. This fundamental doctrine of the absolute unity and immutability of Being acutely raised the problem of the distinction between reason and sense, and threw doubt upon the validity of sense-perception of the external world. Whereas intellect grasps reality as in fact the one and changeless, our senses reveal to us nothing but the many and change. The world of movement, becoming, appearance, is an illusion and a paradox. Such a position as this called for a criticism of the worth of knowledge, and again implicitly emphasised the necessity of undertaking such criticism from the psychological point of view.

The doubts thus cast by all the schools alike upon the validity of sense-perception deepened in the scepticism of the Sophists. All truth, they taught, is relative to the observer; there is no objective truth. Admittedly our senses deceive us. Why should not reason deceive us also? Knowledge is only personal belief; contradictories are equally true if different people hold them to be true; everything is equally false. But even this movement of scepticism had significance for psychology. It drew attention to the personal element in knowledge. It reduced objective truth to personal opinion. And it immediately provoked an examination of the

problem of the value of knowledge which played so great a part in the subsequent shaping of psychological science.

Up to this point Greek philosophy was predominantly objective. It dealt with problems of the physical world to the relative exclusion of man, his mind, its nature and origin. But it led to a view of the relativity of knowledge in the sense that knowledge is relative to the individual possessing it; and this, at the hands of Socrates, Plato and Aristotle, was met by theories in which psychology definitely found its place and was expanded into coherent systems.

The outstanding contribution of Socrates (b. *circ.* 471 B.C.) to psychology was the substitution of the subjective for the objective method. The Sophists had followed the old method and given up the search for truth. Socrates, looking within consciousness rather than upon the external world, tried to determine the conditions of knowledge by an examination of the mental constitution of man himself. He thus established the validity of our concepts as products of logical induction and definition, and so provided a scientific basis for the principles of knowledge and conduct alike. His method was one of questioning, by which he helped his pupils to form for themselves concepts of the changeless natures of changing things. Starting with commonplace sensory experience, he led them by a process of induction to the admission of stable intellectual definitions. He thus countered the sceptical individualism of the Sophists with a doctrine of rational, universal and socially acceptable knowledge; and showed that sense-perception and uncritical generalisation can be controlled by critical and logical thought. Logical concepts thus become both the test of truth and the guide of practical aims. Though moralist and logician rather than a psychologist, Socrates occupies a high place in psychological history because of his insistence upon the nature of the process by which true conceptual (abstract and universal) knowledge is reached, or may be reached, by all men.

The Socratic doctrine was developed by Plato (b. 427 B.C.) in a metaphysical direction, which had its bearing upon psychology, in his theory of Ideas. Plato regarded the Socratic concepts as being objectively existent things. Our knowledge of them is occasioned by, but not derived from, sense-perception. Ideas, accordingly, are not merely personal possessions differing from one individual to another, nor even mental contents shared in common by all men. They are realities in themselves, having an existence apart from the sensory world. For Plato, true knowledge is a grasp of changeless reality, not mere opinion born of sense-perception. Socrates had shown that the possession of concepts was the necessary and sufficient condition of stability in knowledge. But to what objects have these concepts reference? Plato held that knowledge is something received, or given to the mind. Ideas, accordingly, are given; concepts correspond to the realities from which they proceed. To deny this would be to deny the reality of Being, as well as all possibility of attaining to scientific knowledge. But the Ideas do not exist in the changing world of the senses; and we are not in touch with any ideal world. How, then, do we come to know them? Plato answers with a doctrine of reminiscence or memory. In a previous existence we actually contemplated the Ideas; in this life, immersed in a world of flux and change, we recall them to mind.

We may thus distinguish the three worlds, *viz.*, of *concrete phenomena*, *concepts* and *Ideas*. Concepts are the mental representations of Ideas beyond the reach of sense; sensory phenomena are their faint shadows or copies. The importance of this line of thought for psychology is evident. The contrast of sensory phenomena with Ideas, the making of subjective concepts into a real world of objective "universals," emphasising the old distinction of intelligence and sense, sets over against each other two objective worlds, the one the realm of intelligible reality, reason, order and goodness, the other a place of appearance, plurality, disorder and imperfection. But it stresses also subjectivity, and points to a necessary distinction between soul and body. The doctrine of reminiscence necessitates the pre-existence of the soul. This Plato defines as the principle of self-movement, explicitly rejecting the view that it is the harmony of the body. It is the living, moving element in man which perceives, knows and wills. But these processes are on different levels; and the soul is accordingly divided into three parts, the rational, the courageous and the appetitive (desire), having their seats in the head, heart and abdomen respectively. The rational soul alone is immortal, possesses free-will, and is created by God. In a series of transmigrations into new bodies it gradually rids itself of its irrational parts through the conquest of desire by reason. Plato's psychology is built around his theory of Ideas, and moves upon the ideal plane. The nature of the soul is deduced from the theory rather than reached by an examination of mental activities. What is now understood as empirical or experimental psychology is, in Plato's view, part of physics, and therefore no true science; for man, the physical object, belongs to the world of change and becoming and, like all appearance, is not an object of scientific knowledge. Nevertheless, though the rational soul is harboured in the body and thus bound to the world of appearance, by reminiscence it lives also in the ideal world. Plato advanced the two laws of association by similarity and contiguity—that like recalls like, and that, of things experienced together, one tends to recall the other to mind—in support of his theory of reminiscence.

We have seen that the problem of the constitution of the external world led to that of the validity of knowledge, thereby raising psychological issues. The doctrine of the stability of universal concepts had been opposed by a denial of the existence of anything except individuals; and Plato's theory was advanced to bridge the gap, and relate the individuals perceived by the senses to the Ideas. He attempted to do this by deriving the former from the latter; but he failed to show how the derivation comes about either in our knowledge or in the real world.

The problem was taken over by Aristotle (b. 384 B.C.), and its solution by him was made the foundation-stone of his whole philosophy. Like Plato, Aristotle held that there can be no true science of individual objects, for these are continually undergoing change. But he taught that stable intellectual knowledge nevertheless begins in sense-experience, in which only individual existent things are revealed. Instead of regarding experience as a mere occasion for the recall of Ideas, he held it to be the true source of conceptual knowledge. Instead of attempting to deduce individuals from Ideas he reached abstract concepts by induction from concrete instances. Individuals alone are real, universals are products of

the mind discerning identity of nature amidst a plurality of things. Though these may change, the conceptual essences remain fixed and stable. Thus, although intellectual knowledge is essentially dependent upon sense-perception, it is also essentially superior to it. Aristotle's doctrine of knowledge implies radical differences between his psychology and that of his predecessors. In the first place, since scientific knowledge arises from sense-perception, his method is empirical. Natural events are explained on principles reached by induction. Though all involve change, the phenomena of Nature fall into different classes. Some things move (change) because moved by others; some change because they move themselves. The latter are alive; and life is accordingly defined as self-movement, of which the soul is the principle. For Aristotle, soul is not a synonym of mind or consciousness. It is the explanatory principle of every kind of vital process, including nutrition, sensation, movement and thought. Psychology, accordingly, is the empirical study of vital processes as manifested in plants, animals and man. But stress is laid upon sensation and thought; and, because the more perfect includes the less, and thought is a function of the human soul, the study of the principle of thought in man embraces all psychological problems. In the second place, though his method is that of objective observation, he does not neglect introspection. Indeed, Aristotle's theory of knowledge is built upon the introspective distinction of percept and concept (object of sense-perception, object of abstract thought); and a considerable part of his psychology is devoted to showing how we pass from the sensing of the former to a scientific knowledge of the latter. Nevertheless, his psychology is dominated by a metaphysical theory with regard to the constitution of individual things; and, indeed, it is on this theory that he accounts for the transition from perceiving to conceiving. Four principles are necessary to explain the constitution of all concrete beings in the physical order, and the changes which they undergo; matter, form, the efficient (or producing) and the final (or goal) cause. Of these, two are intrinsic principles of the thing in question, the matter and the form. Matter is that out of which the thing is made; marble, for instance, is the matter of the statue. But matter, before the statue is fashioned, is a definite natural substance; and it, in turn, is to be conceived as made out of a "first matter," an indeterminate though determinable principle which cannot exist or be known without form. Form, on the other hand, is the determining principle which actuates matter and constitutes it a definite kind of being, marble, oak, horse or man. It is that into which the thing is made. It is also the object of conceptual knowledge, the changeless essence abiding throughout all the changes the concrete individual undergoes. Applied to psychology, the soul is the form of the body; the matter of which body is formed is a mere potentiality of life which is actualised by soul. Accordingly soul and body, though distinct, constitute one substance only. Man is a unitary being. Furthermore, there is only one soul in man, accounting for all the processes of nutrition, appetite or desire, locomotion and reason. It is not divided, as Plato taught, into parts, but is distinguished into faculties which are the modes of its activity. The conception is a biological one, in which natural species are regarded as unchanging. Plants have nutritive and reproductive souls; animals have sentient souls with powers

of feeling, imagination and locomotion; and man's soul adds to these the powers of reason, deliberation and will. In the biological scheme soul may be considered in an ascending scale, the higher developing from and including the lower. In this conception, psychological data in the modern sense are not abruptly separated from physical ones ; but the observation of vital process is observation of behaviour as function of the soul. Aristotle incorporated an astonishing number of empirically established data into the framework of his theory. He divided mental powers into those of knowing and desire, and connected the power of movement with the latter. He made a study of the special senses, and of the " internal senses " by means of which we perceive, imagine and remember. His explanation of sensory process in general is that the forms of sensed objects are received into knowledge without their matter. Sense is thus regarded on analogy with matter as potential to the reception of forms. To each external sense corresponds a " proper object," as colour to vision; but besides these there are also " common objects," such as movement and shape, which we apprehend by several senses. The five external senses, however, are insufficient to explain perception, in which different kinds of sensations come together. This function is ascribed to a central sense ; from which also the latent images, without which reasoning is impossible, arise in memory. Aristotle states three laws of associative revival of experience—contiguity, resemblance and contrast (like recalls unlike) ; and he teaches that man alone has the power of active recollection and constructive imagination. To account for conceptual knowledge he advances a theory of abstraction. Like the senses, the intellect stands in relation to its objects as matter to form. It requires " information " in order to understand. Its proper objects, however, are the universal essences of things ; and these " intelligible forms " are neither discoverable in the world of concrete beings nor exist apart as Ideas. The only things which exist are individuals. The intellect works, accordingly, upon the material supplied by the senses and illuminates the universal essence enshrined in the individual, thus mentally considering it apart from all individualising characters, such, for example, as time and space. Once rendered intelligible in this way, the object impresses itself upon the passive intellect precisely as the sensible object impresses its form upon sense, and the intellect passes over to conceptual knowledge. Intellect is thus distinguished as active and passive, a power of rendering knowable what was only potentially so, and a power of receiving intelligible forms. In this account of the processes of knowledge from the lowest to the highest stage, the same general principles are invoked. All knowledge originates in sensation ; but there is an activity which discovers the universal elements of thought in the concrete beings of sense. Is this activity a faculty of the soul, or is it something transcendental to the individual man ? Aristotle's thought here is obscure and disputed. But in any case, because the intellectual activities transcend the conditions of matter, he holds that the acting intellect is both immaterial and immortal. On the orectic side (desire, striving, will) Aristotle is no less a pioneer in psychology than on the cognitive (knowing, remembering, etc.). His study of movement led to the view that all perception is accompanied by pleasure or pain. These give rise to impulse and desire. Impulse, appetite

and emotion lead to action. But besides these spontaneous motives there is also deliberate will, which may be described as intelligent desire. Corresponding to the division of cognitive states, desire, will and choice are determined by percepts and images, by concepts and rational insight; and in deliberate choice will is free. Aristotle's conception is that of moderate dualism in which soul and body are not separate entities, but together constitute the individual. On this background he draws the lines of a naturalistic and empirical psychology. The subjective point of view is never lost, although the objective is greatly developed; and psychology takes its place among the biological disciplines as the final chapter of natural science.

There is little of psychological interest in Greek philosophy subsequent to Aristotle. Atomism was reasserted (Epicurus; b. 341 B.C.) with the curious addition of a doctrine of freedom. To this determinism (denial of freedom) was opposed (Stoics), in an interesting anticipation of a view of consciousness as consisting in passively received sensations, from which all knowledge, feeling and will are derived. These sensations become representations when they rise with increasing clearness in consciousness. These two points mark a phase of development in the concept of the mental as contrasted with the physical, and also foreshadow the modern doctrine of the subjective variation of clearness in ideas.

The last stage of Greek speculation has even less interest for psychology. Attempts were made to unite Jewish religious beliefs with the philosophy of Plato, Aristotle and the Stoics. The number theory and the theory of Ideas were revived; but philosophy tended to degenerate into mysticism. The chief significance of these movements, so far as psychology is concerned, is that, infiltrating into Christian tradition, they influenced the thought of so great a psychologist as St. Augustine (b. A.D. 354).

PSYCHOLOGY IN EARLY CHRISTIANITY

With the spread of Christianity, the growing need of expressing its teaching systematically and providing an apologetic for it resulted in Patristic philosophy (*i.e.*, that of the Church Fathers), which arose in subservience to religious dogma. In this there is little relevant to psychology before Augustine except the common distinction of soul and body, the doctrine of immortality, and an increasing precision in the concept of personality. In Augustine, however, we find a psychologist of outstanding eminence, who left the impress of his thought upon all subsequent speculation. Two pivotal ideas stand out in his philosophy: God and the human soul. The great stress laid by Christian teaching upon the value of the individual raised problems concerned with the personality, nature, origin and destiny of man. The theological doctrines of the Trinity and the dual nature of Christ accentuated those problems; and in such a setting Augustine's psychology was developed. Familiar with nearly all the philosophies of antiquity, he is in the main a platonist; but he incorporated also into his system many results reached by other thinkers. His chief explicit contribution to the science is his vigorous assertion of the value of the introspective method, whereby he defines the subject-matter

of psychology as the inner world of consciousness, distinct from that of physical Nature. The soul is known in self-consciousness as a simple, immaterial and spiritual being. This he proves from the fact of sensation, using a neo-platonist argument: *viz.*, the soul is everywhere in the body, since it receives impressions coming from all parts of the body. It is therefore immaterial; for it is no one part of the soul which perceives, but the self as a whole. Further, he shows that it is immortal, on the ground that imperishable concepts are discovered within it; and what contains the imperishable must itself be immortal. The platonic character of these proofs is evident; but the point made is that they are based upon introspection, which reveals mental life as a continual activity of the soul. This shows itself in three functions—intellect, will and self-conscious memory—which are not distinct from the soul itself. The fundamental principle is will, which moves intellect and inner sense to action, and is both ethically and psychologically free. Man is therefore by nature a spiritual soul making use of a body. He acts upon the body, but is not acted upon by it. The senses, accordingly, engender neither sensation nor thought; it is the soul which gives birth to both. Thus all ideas are innate, and are formed in the soul under the influence of divine illumination. Augustine classifies mental powers as faculties of sense and faculties of spirit. The former include appetite and sensory knowledge arising in connection with, but not dependently upon, the external and internal senses. The latter are common sense, imagination and memory. Faculties of spirit embrace will, understanding and intellectual memory. In Augustine's view the source (which is revealed by introspection) of mental activities, though united to the body, has its own substantiality, and can be studied in its own right. In considering its origin, he hesitates between creationism (the creation of the soul from nothing by God) and traducianism (the derivation of the soul of the child from those of the parents); but on theological grounds inclines to traducianism. A great gain for psychology is registered by Augustine. In separating the inner from the outer world he justified the study of the former as a distinct branch of knowledge; and in insisting upon the immediacy of self-consciousness in reflective thought, he drew a sharp distinction between the self as subject and the objects of its knowledge, thus furthering the dualistic point of view. His influence in psychology is everywhere traceable throughout the Middle Ages, comes to more explicit development at the beginning of the Modern period, and is manifest in many directions of contemporary thought.

PSYCHOLOGY IN THE MIDDLE AGES

While Platonism colours Patristic speculation, Aristotelianism is the hall-mark of Scholasticism (the philosophy of the mediæval Churchmen), though both streams flow together and intermingle in mediæval thought. The principal representative of Aristotelian tradition is Thomas Aquinas (b. 1225, ? 1227), who stands out pre-eminently in the philosophical development of the thirteenth century. More than ever before, psychology becomes in his hands a comprehensive body of unified doctrine, easily separable from the rest of philosophy though intimately connected

with it. Aquinas is concerned with the nature of man in order to infer from it his origin and destiny. He accordingly examines all human activities to determine what human nature is and what it implies. He follows closely the main lines of Aristotelian thought, but develops and alters the traditional teaching in several important respects. In his view, all human activities are functions of faculties proper to man as a composite of matter and form ; but the faculties are due to form, or soul, and not to matter. The existence of the soul is known in any one of its activities ; but its nature as a spiritual actuality is only grasped by diligent reflection upon the characters they display. Aquinas distinguishes the soul from its faculties and these from each other, however, because of irreducible differences in vital operations which cannot be accounted for by any one single principle. Here he parts company with Augustine and clarifies the obscure teaching of Aristotle. The faculties are the proximate grounds of the vegetative, cognitive and appetitive functions. Aquinas, however, was principally interested in knowledge and desire as expressions of the purely mental life. He distinguishes knowledge into two orders, a lower, or sensory, form and a higher, or intellectual, kind. In general, his explanation of the processes of knowing is Aristotelian. The joint activity of the object and the knowing subject engenders a mental image representative of the object. Sensation, perception and sensory appetite are regarded as psycho-physiological processes, stress being laid upon their physical aspect. Here the interdependence of organic function and mental process is in striking contrast with the Augustinian view. Being organic, the senses are passive powers, reacting to stimuli by the formation of sensations, which are combined into images by an internal sense. Sensory processes, however, acquaint us only with individuals. To the list of internal senses Aquinas adds an estimative sense, the function of which is sensory judgement with respect to the useful or harmful character of concrete objects. Animals possess this sense ; but in man it is a kind of reason which deals with particulars. Intellectual processes also are accounted for on Aristotelian principles. Universal concepts are derived from sensory images by the process of abstraction and are subsequently universalised by a purely mental activity. Passive and acting intellects are distinguished to meet the requirements of the general theory of knowledge ; but Aquinas clearly teaches that both " intellects " are intrinsic faculties of the soul itself. Naturalism here replaces the vague mysticism which was taught by the Arab commentators of Aristotle and is traceable perhaps even to Aristotle himself. A notable advance towards a purely scientific psychology is thus made. With regard to orectic processes, Aquinas again divides appetite or desire into the two classes of sensory and rational, which operate on different levels. Sensory desire inclines us towards objects perceived or imaged ; and its arousal gives rise to passions or emotions. These passions were the object of careful study by the Scholastics in connection with moral philosophy. Rational desire, or will, inclines us towards abstract Good, in respect of which its activity is absolutely determined. The will is free, accordingly, only with regard to contingent, or relative, goods. One general law, however, regulates the life of desire, whether sensory or rational. Some kind of knowledge must call the appetitive powers into action. Knowledge is accordingly superior to will. In contrast with the

Augustinians, and particularly Scotus, Aquinas is thus an intellectualist. The results of his analysis of mental process lead to the Thomistic conception of human nature. Since the soul is only the substantial form, the proper object of study is man himself and not the soul alone; but man acts as he does in virtue of being "besouled." Further, one soul only constitutes him a spiritual as well as a material being. The doctrine of plurality of forms, held by other Scholastics, was explicitly rejected by Aquinas. Nevertheless, though form of the body, the soul is a spiritual and substantial principle, independent of the organism in its highest activities of conception and thought. It is accordingly immortal; not, as Aristotle probably held, in the impersonal form of the acting intellect, but in the personal immortality of its whole being. It is created by God, and was created to enjoy eternal happiness in intellectual union with God. Though presented in a framework of theology, the psychology of Aquinas marks a distinct advance. It unites the biological view of Aristotle with the refined form of animism taught by Plato and Augustine. It thus avoids the dualism which makes two entities of body and soul, which destroys the unity of the individual, and raises insoluble problems with regard to the relation of mind and matter. At the same time, it leaves room among the natural sciences for psychology to deal with mental, as distinct from physical, phenomena, and justifies its existence as a special science with its own subject-matter, point of view, methods and principles.

In contrast with the psychology of Aquinas, several differences in that of Duns Scotus (b. 1274, ? 1266) have a bearing on more recent developments. Adopting Augustinian and Aristotelian doctrines, with personal modifications of great originality, Scotus agrees in the main with Aquinas; but he teaches that we have an intellectual knowledge of individual things. Besides abstract and universal knowledge, which is clear and distinct, we also know individuals in a confused manner simultaneously with our sense perception of them. This indicates a growth in clearness of mental contents arising from experience; and is a second anticipation of an important current doctrine in psychology. Again, because of its absolute freedom (knowledge of the Good being a condition, but not the cause, of will-acts) will, rather than intellect, is the pre-eminent faculty. This is in line with recent developments of Hormic psychology (impulse, striving), and even with certain postulates of Behaviourism (*see below*). Lastly, though man is the composite resultant of soul and body, Scotus teaches that a "bodily form," as principle of organic structure, also enters into his composition. Though he did not develop the view, this implies a step towards that of Descartes, in which soul and body are conceived as two separate entities.

The general results of Scholastic speculation that are most significant for psychology, are progress in the analysis of cognitive, volitional and emotional processes, as well as the establishing of relations between them; the making explicit of the essentially unitary nature of consciousness; and the development of a theory of personality centred upon the intuitive awareness of the self as a real psychical entity.

The movement reached its zenith in the thirteenth century. After long incubation it rose swiftly to maturity; but hardly less swiftly decay set in. The springs of inspiration dried at their source. Growth and development

were arrested; and mere dialectic (argument and hair-splitting) took the place of empirical analysis and the closely reasoned speculation built upon it. So far as psychology is concerned, there is an almost complete blank between the thirteenth and sixteenth centuries.

THE BEGINNINGS OF MODERN PSYCHOLOGY

With the rise of the scientific movement, however, it was not long before psychological problems appeared in a fresh setting. At first, as in Greek philosophy, interest was primarily centred upon external Nature; but even Bacon looked forward to the time when empirical methods should be applied, not only to physical and physiological events, but also to the interplay of ideas and the activities of the will.

The two great forerunners of modern psychology are Descartes (b. 1596) and Locke (b. 1632), from each of whom derive influences which have fundamentally affected psychological thought up to the present day.

Descartes' philosophy began in a universal, methodic doubt which prepared the way for the discovery of incontrovertible truth; and Descartes found this truth, from which he proposed to deduce all others, in the fact of personal, self-conscious thought:—" I think; therefore I am." One may doubt all else, even one's own bodily actions; one cannot doubt such self-evident intuition. Upon the clearness and distinctness of this truth he based his criterion of valid knowledge. Whatever is as clear and distinct as self-consciousness is true. But for the supposition that some power superior to our own might deceive us in all things, Descartes might at once have applied this criterion to the clear and distinct idea of extension as revealing the nature of matter, and so have raised the antithesis of body and mind. Instead, he turned to the idea of God; from which he " proved " the existence of a Being whose goodness and wisdom guarantee the veracity of our faculty of knowledge. Clear and distinct ideas (innate in the sense that the mind is predisposed to accept them), and whatever is deduced from these, are accordingly valid. Among such innate ideas is that of the nature of matter as consisting in extension; and this is sharply distinguished from sensory perceptions, in which bodies appear to be coloured, sonorous, odorous, and the like. These qualities are obscure and confused subjective appearances, and not objective properties of things. The essence of body, accordingly, is to be extended; and the essence of mind is thought. Here is a metaphysical dualism in which the main problem that exercised subsequent speculation arises. What is the relation between body and mind? The antithesis is further emphasised by Descartes' teaching that animals are automata without feelings or power of self-movement, which obey the physical and mechanical laws that regulate inanimate Nature. Only in man's case a thinking mind is infused into the automaton by God. Thus essentially opposed to body, the human mind must somewhere come into contact with it to explain the reception of sensations and the production of movements. Descartes locates this contact in the pineal gland at the base of the brain. Here the mind receives feelings from the nerves, and brings about motions in the body by way of the " animal spirits " flowing in the

nerve channels. Sensorial life thus has a physiological basis, whereas true thought is wholly mental. The automaton doctrine disposes of the soul as the principle of life in man, and substitutes a thinking mind joined to a mechanically regulated body. The main point brought out in all the detail of Descartes' psychology is the refining of the concept of mind to include conscious events, and the reduction of sensory and motor processes to physical ones. There is interaction between body and mind, but complete disparity of nature. This doctrine bore fruit later, when interest in the body-mind problem gave place to empirical psychology, in a clearer definition of purely mental phenomena.

The line of thought deriving from Descartes was largely occupied with the psycho-physical problem set by him. The Occasionalists, distinguishing between occasion and cause, held that the body does not cause sensations nor the mind movements, but that physical stimuli and conscious volitions are mere occasions of sensations and movements which, in fact, are caused by God. Leibniz advanced a theory of divinely arranged, or pre-established, harmony. Soul and body do not directly influence one another; but their actions run in parallel lines. Spinoza, more radical, made of mind and matter two aspects of the one underlying reality, God. Instead of Descartes' interaction, these philosophers asserted psycho-physical parallelism in solution of the difficulty.

While on the Continent rationalism continued its development, in England the foundations of empirical psychology were being laid. Already Hobbes had attacked the concept of a substance-mind, and taught that mental process is a function of the body, and reason the product of sensation. Here lay the germ of modern materialism and associationism (the doctrine that all mental processes are accounted for as associations of ideas). But we must look to Locke for the full use of the empirical method in psychology. Instead of the deduction of conclusions from the supposed nature of mind, he uses the method of induction to reach a scientific knowledge of the principles of mental life. He thus rejects metaphysical and mystical accounts of the origin of knowledge (innate ideas, pre-established harmony, divine inspiration) for a theory based upon observation. Children, he argues, uneducated people and savages show evidence that knowledge originates in experience. At the outset the mind is a blank tablet. How, then, do ideas become inscribed upon it? Locke teaches that all ideas derive from experience by sensation and reflection. By sensation we perceive the external world as possessing qualities and quantity; but the (secondary) qualities, colour, odour, etc., are subjective only. By reflection we are acquainted with the inner activities of understanding and will. Ideas are simple or complex, the former simply given to the mind, the latter actively formed in it by repetition, comparison and combination of elementary ideas. Mental powers, however (*e.g.*, sensation, memory, imagination, understanding, will), are not separate entities, but only ways in which the mind acts. Locke's distinction between sensation and reflection shows that mental process is not merely a mechanical interplay of ideas. Mind has the power of reflecting upon the course of its ideas; and in reflection higher ideas (*e.g.*, power, cause, unity, relation) are formed. Thus universal ideas are explained on an empirical basis; a protest against the doctrine of innate ideas. Locke deals more cursorily with the

active powers of the mind. Pleasure and pain are kinds of sensation; will is a mental movement due to "uneasiness"; and both arise in course of the interplay of ideas. His empirical analysis is clearly a forerunner of later analyses of consciousness into contents and states; but Locke never disputed the existence of a substantial, active mind. He accepted this as a fundamental datum. It was the existence of the external world that needed explanation; and our certainty of this, he taught, depends upon the impressiveness, or "liveliness," which characterises certain subjective sensations.

The last statement shows how the next analytic step could be taken by Berkeley (b. 1685). Already secondary qualities had been denied of matter and made subjective. For Berkeley the primary qualities (extension, impenetrability, etc.) also became mental states no less than the secondary. The external world, accordingly, has no reality except in mind: to be is to be perceived. All experience is subjective. This Berkeley argued in his *Theory of Vision*, in which he showed how our idea of tridimensional space results from the association of sensations of sight and touch. Ideas, however, presuppose some cause upon which they and their sequences depend; and, having shown that no material reality exists, Berkeley asserts that their cause must be spiritual. Moreover, since the sensory ideas do not depend upon our personal wills, it follows that it is not we, but the eternal, uncreated spirit that produces them. Matter does not exist; spirits alone exist: God and human minds. And the mind is a simple, active being, revealed through experience. Sensory perceptions are ideas in the mind of God, who causes them to appear to us. The perceiving mind is reason, as contrasted with the acting mind, which is will.

Berkeley's idealism forms a stepping-stone between Locke and Hume (b. 1711), whose psychological system had an immense influence upon the development of the science. A radical empiricist, Hume set out to make an exact analysis of mental powers and capacities. He begins by reducing mind to the sum of its contents. He rejects Locke's distinction between sensation and reflection, and substitutes a law of association for the dynamic activity of the mind. The fundamental mental states are the lively impressions which originate both in outer and inner experience, and their fainter copies, or ideas. We thus have as original elements of mind visual, auditory, tactile, etc., impressions and ideas, as well as pleasures, pains and efforts; and these are the sole data of knowledge. Connected, compounded and succeeding one another in virtue of association by contiguity, similarity and causal relationship, they constitute consciousness; which is accordingly conceived as an agglomeration of sensations regulated by the principles of association. Where Hartley (b. 1705) used associated nervous processes to explain the occurrence and order of mental events, Hume postulates only mental elements and mental laws, thus avoiding any appeal either to body or to mind in explanation of consciousness. Impressions, ideas and laws of association take the place of brain processes, as well as of any really active principle of thought. Even the self is reduced to a mere bundle of associated ideas. While Locke reasoned away secondary physical qualities and their unknown substratum, while Berkeley extended the reasoning to primary qualities and physical substance, Hume used the same line of attack upon

the mind itself, and nothing substantial remained. Hume's empirical analysis of causality, which reduces even will to sensations, is equally radical. The causal relation is one in which two ideas are constantly experienced in a sequence; and repetition of such experience in the past sets up the habit of expecting a similar relation in the future. But there is no real efficiency in the "cause." For, if we analyse the notion of power it contains, we find no more than the sensations of effort we ourselves experience when we move external bodies, or those of the impact of bodies upon us. Here there are only several sensations in constant sequence (feeling of effort and movement of limb; sensations of moving body and impact). No real power is involved in either case. We read our sensation of effort into sequences of external events, and come to an illusory belief in real power, or energy, resident in the "cause." We experience effort and believe in our own causality in willing. But this is illusory also; for, though perceived movements follow upon will-acts, this is in fact apprehended only as a sequence of strongest motive as inner event and change of place as outer event. Feelings of pleasure and pain, corresponding to impressions, give rise to emotions, which are thus also reduced to sensations and become associated with ideas. The system is one of radical sensationalism, in which all mental events are hypostatised; and psychology is presented as a naturalistic and positive science, the task of which is to investigate the structure of consciousness. It is no longer the science of soul or of mind, but of mental phenomena. Hume's influence in psychology can hardly be over-stated. He was the founder, with Hartley, of the Associationist and Structuralist schools which have lasted almost to the present day. Transferred to France, his doctrines were modified into a still more complete sensationalism by Condillac (b. 1715), who omitted the principle of habit as accounting for mental synthesis. In Britain and abroad, these movements provoked reactions in the Scotch "Common Sense" philosophy and French Eclecticism. Hume's psychological doctrines were developed in the two contrary directions of spiritualism and materialism. Everything being reduced to sensation, it was easy to construct the world out of ideas, as Berkeley had done; and scarcely less easy to identify sensations with states of the brain, as did Hartley, Priestley and the French Encyclopædists. Finally, it was Hume's phenomenalism and "scepticism" which awoke Kant from his dogmatic slumber to labour at his Critical Philosophy.

Three further influences have contributed to the shaping of contemporary psychology. Already in the movements of Cartesian rationalism and Locke's empiricism, we find many of its elements; but the speculations of Leibniz (b. 1646), the philosophy of Kant (b. 1724) and the formulation of the theory of evolution by Darwin (b. 1809) supplied other exceedingly important ones.

Leibniz's conception of the world is wholly psychological. Unlike Descartes, who set himself to doubt all previous principles and conclusions of philosophy, Leibniz wished to establish a system in which Greek, Mediæval and Contemporary thought would be reconciled. To this end he advanced a theory of reality of which his doctrine of monads, principle of pre-established harmony, and law

of continuity, are the cardinal points. Mind and matter, divorced by Descartes, were to be reconciled in a panpsychism (universe in which all that exists is held to be spiritual). Leibniz begins with the concept of mental substances as independent activities, essentially individual, yet together constituting a world. These active forces he calls "monads." He conceives them, on analogy with material atoms, as simple, indivisible and indestructible; but he also endows them all, in varying degree, with the power of mental representation. The human soul is such a monad, conscious of what it represents. Others represent the universe confusedly or even unconsciously, and so reflect every other monad in existence. The world consists of these immaterial monads in an ascending scale of perfection, their place being determined by the degree of clearness with which each actively represents the rest. Thus the lowest (inorganic) monads manifest unconscious representation in attraction and repulsion only. Plants are "sleeping monads" with unconscious ideas, or formative vital forces. Animal soul-monads represent obscurely in sensation and memory; while the human soul is capable of forming clear and distinct, as well as adequate concepts. There is thus an absolute psychical continuity between the lowest monad and the human soul. Though the conception is vitalistic, it is not that of Aristotle; for, instead of interpreting mind in terms of life, Leibniz interprets life in mental terms. Bodies are aggregates of simple monads apprehended in obscure sensory perception as spatially and temporally ordered, but in clear analytic thought as aggregates of active spiritual entities. No monad, however, can act upon another, or receive influence from it. Their activity is wholly immanent, or within themselves. A problem accordingly arises with regard to the correspondence of the succession of ideas in the mind with the movements of the monads of the body. Leibniz solves this problem by postulating a pre-established harmony between them. Soul and body agree like two clocks, originally set going by God and absolutely synchronised. Remote as his doctrine may appear from contemporary psychology, it nevertheless has had considerable influence upon it. The assertion of unconscious mental activity is accepted to-day. The concept of growth in clearness of ideas from unconsciousness to full apperception, or clearness (as in Scotus and the Stoics), has born fruit in many directions. And the doctrine of the essential activity of self-consciousness as dynamic will (Augustine), which determines the course and clarification of representations in consciousness, has left its impress upon the science.

The philosophy of Leibniz was a consistent and closely reasoned system. At the hands of his follower Wolff (b. 1679) it became little more than a series of dogmatic assertions. The meeting point of Dogmatism and the scepticism of Hume in the mind of Kant gave rise to the Critical Philosophy. Kant opposed all speculation which goes beyond empirical experience without first having justified its procedure by a preliminary critical examination of the extent and limitations of knowledge. Impressed by Hume's analysis of causality, which regarded belief in the causal relation as being due to a subjective element of habit or custom, and concerned to distinguish the universal element in knowledge from the particular elements of experience, he was led to the hypothesis that, instead of the mind conforming to objects in knowing them, objects conform to

the mind. The manifold items of experience become unified and stamped with the impress or form of mentality. Since nothing necessary and universal can come from experience, space and time (the universality and necessity of which are shown in mathematics) must be subjective forms, prior to all experience, which are impressed upon sensations. They are the pre-requisite conditions of external and internal sensation. Things-in-themselves are neither spatial nor temporal; co-existence and succession are phenomenal—appearances only—and accordingly are only subjective. Analysis of judgement shows further that there are subjective categories, forms of thought not derived from experience, under which phenomenal knowledge becomes organised. Since these, like the sensory forms, are logical and subjective conditions of knowledge, reality as it is in itself remains unknown. By speculative knowledge we can reach neither to the real self, the world nor God. Nevertheless, Kant's doctrine of the unity of apperception and of the categories has profound significance for psychology. The organisation of disparate items of experience into mental objects with spatial and temporal characters, their interpretation by inclusion in a category, points to more than was admitted in Hume's sensationalism. Though we cannot know its nature, the doctrine reintroduces the notion of a self which actively organises experience. Moreover, even if we cannot grasp things-in-themselves, we do know our own organised experiences; and it is thus possible to formulate psychological laws on the basis of experience, even in the absence of knowledge of the soul. Kant's treatment of willing and feeling allows him to bring back into philosophy what his analysis of pure reason had made him reject. Passing from consideration of thought to that of action, he finds a "categorical imperative" in the consideration of duty. This presupposes the freedom of the will, the existence of God and the immortality of the soul. The ultimate value does not lie in the region of knowledge, but in that of will and feeling, where teleology, or the seeking of ends and goals, and æsthetic appreciation are experienced. Feeling, willing and knowing are three separable faculties. Though Kant declared that an exact science of psychology was impossible, his general position indicates how such a science might be built up. It must no longer be concerned with souls, but must study experience; and, to be successful, must employ mathematical method. In rejecting metaphysics and "subjectifying" physical science by introducing mental elements into its construction, he revealed a point of view for the study of mental phenomena which greatly influenced subsequent speculative thought. His place in psychological history is indicated by his comparison of himself with Copernicus as a revolutionary in science, making objects conform to mind rather than making the mind merely reflect objects. The implications of this reversal of theory have remained a permanent gain.

While in Britain and France empiricism developed, in Germany psychology never wholly lost its metaphysical background. Herbart (b.1776) combined elements of the philosophies of Kant and Leibniz, but laid greater stress upon introspection. He rejected the doctrine of unitary faculties; and postulated a simple, active soul as the subject of mental life, teaching that ideas are due to its reactions upon other beings ("Reals") with which it co-exists. He attempted to express all psychical

activities in mathematical formulæ and to reduce mind to a kind of mental mechanics. Conscious states are thus regarded as an equilibrium of opposing forces. Ideas are conceived as complexes of sensations; but instead of passive links between them, as in associationism, he postulated active mental forces which are conceived as summating algebraically. Ideas struggle together or ally themselves in consciousness. The conception suggested an unconscious region of mind into which ideas, that are too feeble for successful competition, sink, to rise again when their opposing ideas weaken, or when their own force increases by alliance with others. The dynamic alliance of ideas, to which fresh material is assimilated in learning, is called by Herbart an " apperceptive mass." It is conceived as an aggregate of active past experience to which new ideas ally themselves. Apperception is thus the active combination of ideas into a growing unity; the dynamic background of experience makes the assimilation of fresh material possible. This conception was, and still is, of great fruitfulness in educational theory and practice. Herbart's aim was to make psychology an exact empirical science, with practical applications. Though his dynamic of ideas did not prove successful, he certainly advanced the study in both these respects.

EVOLUTION AND PSYCHOLOGY

The positivistic trend in England was given fresh impetus by the restatement of the hypothesis of evolution and the vast amount of evidence collected in its favour. Though formulated in several quarters before his time, it was the influence of Darwin in its support, more than any other, that went to shape contemporary psychology. Both Lamarck and Darwin held that acquired characteristics (or at least some) are cumulative, and inherited from previous generations, and that these characteristics are acquired not only by the action of the environment upon the organism, but also, in part, by the efforts of the creature to adapt itself to its environment. This implies a psychological factor in evolution; and, though the inheritance of acquired characteristics is not now generally accepted, the view proved to be an incentive to research and a workable principle of interpretation. Darwin's psychological interests were extraordinarily broad and profound. He applied the principle of natural selection to problems of instinctive behaviour, emotional expression in man and animals, protecting and attracting traits, and the like; and in the *Descent of Man* he extended the same principle to higher mental processes also, and showed the similarity between human reasoning and processes of the animal mind. The influence of the evolutionary hypothesis upon psychology was enormous. Like the saturated solution of a salt into which a crystal is dropped, current psychologies began to crystallise round it. The mental gulf between man and the rest of the animal kingdom was bridged. Genetic views of the mind came speedily to replace static ones; and many acute psychological observations, from Aristotle onwards, were found to fit readily into the new naturalistic scheme. The stage was fully set for the development of contemporary psychology. The first thoroughgoing application of the new principle was made by Spencer (b.1820) within the framework of associationism. On analogy with

the derivation of complex organic structures from simpler forms he derived all more complex mental states from primitive sensation, or feeling, elements which accompany elementary nervous process. Intelligence was similarly derived, through instinct, from primitive reflex action. Mental products are, accordingly, capable of analysis into simple elementary forms; and by association these are bound into wholes, not merely in the developing mental life of the individual, but racially also. Associations formed in early social experience, animal or human, are stamped in and transmitted by heredity. There is thus a reconciliation of innate ideas and experience; the universal and necessary elements of thought coming, not from individual experience, but from that of the race. They are the result of past history recorded in hereditary neural arrangements of the brain. Feelings, emotions and will are reduced to aspects of complex sensory processes, the complexity of which is conceived on analogy with chemical compounds, rather than as the result of summation or mere addition. Here is no hint of any synthetic or creative activity of a conscious self in respect of its own mental contents; the psychology is a wholly structural one. Indeed self, as mind-substance, is for Spencer only an unknowable something postulated to explain persistence and unity, in spite of all changes, in the aggregate of states of consciousness. Like all associationisms and structuralisms Spencer's psychology is now outgrown. It was none the less a contribution of worth, focussing attention upon the naturalistic evolution of mind as a subject of special study. It indicated the place of psychology among the other biological sciences; and, by insistence upon the racial derivation of individual mental characteristics, related the science closely to sociology.

A second consequence of the acceptance of the Darwinian hypothesis was the application of the concepts of variation, selection and adaptation to the study of individual differences. Though experimental work had shown that people differ in respect of sensory acuity, quickness of reaction-time, and the like, it was Galton (b. 1822) who first investigated the problem of individual differences on a large scale in his studies of hereditary genius, mental images, mental number-forms and similar matters. Even more important was his contribution of a statistical method, which was to prove of enormous service in psychological investigation. In order to find the relation between mental qualities, which cannot directly be measured, we require some device by which we can ascertain how far they tend to go together. Such a device Galton provided in the "coefficient of correlation," which has since so been developed and perfected as to be of inestimable value in psychological research. The raising of the problem of individual differences, and the creation of this instrument of research, entitle him to a foremost place as a pioneer of contemporary psychology.

A third consequence of the introduction of the hypothesis of evolution was the extension of psychology to the comparative study of animals, primitive peoples, children and abnormal persons, with a view to discovering genetic relations between them and normal adults in respect of mental process. Whereas previous interests had chiefly been directed upon the normal adult mind, either deducing its characters from the nature of the soul, or inducing its principles from empirical observation, interest now

was largely centred upon evolutionary connections. Behaviour in all its forms, interpreted on analogy with the personal conscious behaviour of the student, was closely observed by naturalists; and observation in experimental conditions later on took the place of uncontrolled field work. A vast and growing literature upon animal, child, primitive and pathological psychology began to accumulate. Experiments upon creatures, ranging from unicellular organisms to anthropoids and young children, were multiplied; and the original impetus, far from spending itself, has steadily increased up to the present, every school of psychology drawing inspiration from the comparative observation of behaviour. The chief dangers of this line of attack have been an undue tendency to interpret the behaviour of animals and children as if they were human adults, and the " behaviouristic " tendency to dispense with consciousness altogether in interpreting the actions not only of lowly organisms but even of man himself.

EXPERIMENTAL PSYCHOLOGY

Already experimental psychology had begun, in a small way, in the attacks made in physical and physiological laboratories upon problems connected with sensation. Both psychophysics (the correlation of mental with physical changes, when physiological conditions are kept constant) and psychophysiology (the correlation of mental events with physiological changes) had made headway. The growth of the experimental spirit in psychology is indicated, as we have seen, as far back as Herbart. It is illustrated by such work as that of the physiologists Weber and Fechner, who established the psychophysical law of sensation (*viz.*, sensory intensity increases in arithmetical progression while the stimulus is increased geometrically). It was advanced by physicists like Helmholtz, who investigated vision and hearing as well as the temporal differences of reaction-times. It came at length to a head in the establishment by Wundt of the first exclusively psychological laboratory at Leipzig. Here not only sensory processes, but higher mental processes also—memory, imagination, attention, association, feeling, emotion, thought and will—were proposed for investigation. Within a comparatively short time psychological laboratories multiplied throughout Europe and America : and at the present day there is hardly a centre of psychological teaching where experimental work, forming the nucleus of training and theoretical teaching, is not carried out. Besides observation and introspection, the ordinary methods of physical science are employed; and within the past few decades statistical treatment of the data of research has increasingly been followed up. These methods, becoming progressively more refined and adapted to the subject-matter, have proved not only fruitful in their application to special problems, but illuminating in general psychological theory also.

The multiplication of centres of research, and the continual splitting up of larger problems into their parts for detailed solution, have led to increasing specialisation in psychology and a shift of interest even greater than that caused by the introduction of the empirical standpoint. The old problems concerned with soul, mind or consciousness, its relation to

body, its origin and destiny, have largely been thrust out of view by preoccupation with more immediate issues. They have been left to the philosophers, while experimental psychologists have busied themselves more and more with the investigation of mental processes as such in all their detail. This does not mean that the more fundamental problems are no longer urgent. It means a distribution of labour, in which the experimentalists are content with the spadework that yields immediate practical returns. For psychology to-day is in the position of physical science when this made its greatest advances, and applied its discoveries in every direction to social and material well-being. There also more fundamental problems lay in the background, which to-day the mathematical physicists are attempting to solve. It is not unduly optimistic to hope that the immense amount of material being gathered together in experimental psychology will lead to an empirically established and acceptable view of the nature of the conscious principle.

SOCIAL AND COMPARATIVE PSYCHOLOGY

Another line along which psychologists have been working, is the investigation of man in his social aspects. This also may be traced to the influence of evolutionism upon the science. It has led to the formulation of doctrines of social and dynamic psychology which supplement the data derived from the experimental investigation of mental process, and link up comparative with normal, abnormal and pathological psychology. No longer considered as isolated individuals in a merely physical environment, the reactions of organisms, and particularly of man, to social stimuli were investigated. What are the springs of action which instigate behaviour in response to such stimuli ? The hormic psychologies provide an answer. The original drives to action are the inborn psycho-physical, or body-mind, dispositions, differing in different organisms, to behave in typical ways upon external stimulation whether physical or social. Profusely illustrated in the behaviour of lower animals, and especially of insects, they are the primary motives of all behaviour, in the service of which all the cognitive powers have their existence and meaning. It has been said that intelligence is a tool at the service of instinct. How far down in the biological scale animals are to be credited with consciousness analogous to ours may be disputable ; but there is evidence of adaptation by insight, or by trial and error, which makes learning possible at a very low stage indeed. Such cognitive powers as animals may possess are accordingly regarded as serving the original hormic forces. The action of these forces, however, may become modified by consciousness in various ways. Fresh kinds of stimuli may become substituted for those originally adapted to release them. They may become specialised to a single individual belonging to the class of stimuli apt to activate them, and so be more readily called into exercise by that individual than by others. In creatures capable of mental abstraction and conception, moreover, the hormic drives may come into play in response to stimulation by abstract and conceptual ideals. On the other hand, modifications of original forms of behaviour, or behaviour-patterns, also come about dependently upon processes of trial and error and of insight. This is especially noticeable in

human social conduct, in which the goals of instinct are not as a rule directly attained, but are secured through means that are often of an exceedingly circuitous kind. Thus all the social machinery of law, industry, commerce, and the like are human inventions used to secure the instinctive ends prescribed by Nature. Hormic psychology presents a very complete dynamic view of human behaviour, into which the details of comparative and experimental psychology naturally fit. It thus reflects the best features of pre-scientific psychology, and provides a broad foundation for the investigation of the nature of the principle of conscious life. In its recognition of dispositions, drives or tendencies, it emphasises the part played by the unconscious in the determination of consciousness; and, by extending mentality beyond the region of awareness, it points to a mental vitalism comparable with that of Aristotle.

Having indicated the main directions in which the currents of contemporary psychology are flowing, it will be convenient to summarise the present position of the science under several heads, roughly corresponding to the division of mental process into cognitive, conative and affective. Though there may be some unavoidable overlap, this will enable us briefly to review and contrast the chief schools of psychological thought in existence at the present day.

From what has been said with regard to hormic psychology, it will be clear that the investigation of cognitive processes has its bearing upon the explanation of behaviour; for modification of inborn, or connate, behaviour-patterns depends upon forms of cognition. From the lowly organism which slightly alters its native reaction to a stimulus when confronted with difficulty in attaining its end or maintaining its "psychic equilibrium," to the human being who plans a long and complicated series of actions leading to some remotely conceived goal and strives to attain it, the strivings are determined by cognition, but at very different levels. No one of us, however, has direct insight into the mind of any creature other than himself; and we must accordingly interpret behaviour at all levels, on analogy with our own, and refer it to mental processes which we immediately apprehend in introspection. Analysis of human consciousness must yield all our principles of explanation. Such analysis has led to the formulation of four principal theories of cognitive process which are advanced to-day. All except one are protests against the associationisms and structuralisms in which mind was reduced to the sum total of its phenomenal elements or states. The remaining one is an extension of associationism to physiology; and it contrives to do away with consciousness altogether. Since we have already considered associationism in dealing with Hume and Spencer, no recapitulation is necessary here. We need only recall the main point of the theory; *viz.*, that all processes of consciousness whatsoever are reducible to sensations regulated by associative laws. Apart from the distortion of many mental phenomena by forcing them into the too rigid framework of the theory, the omission of the functional and dynamic aspect of mind was fatal, as is shown by all contemporary presentations of psychology, including Behaviourism. Dynamic activity is smuggled in by way of neural process, even if it is not admitted right of hospitality in consciousness. Associationism has been ousted by contemporary systems, because it was inadequate to explain

vital factors of personal experience. It had no place for emotional activity, purposive striving, or creative thinking.

BEHAVIOURISM

In a sense, however, it has taken on a new lease of life in the more extreme form of Behaviourism; but at the price of sacrificing consciousness altogether. Behaviourism is not only a psychology without a soul; it is psychology without either mind or consciousness. It proposes that the consideration of psychologists should be limited to external and observable behaviour; and then proceeds to explain behaviour, in a strictly deterministic manner, in the light of the principle of contiguous association. In this theory, all forms of behaviour in animals, all kinds of human conduct, no matter how socially desirable or morally elevated, are conceived as built upon the foundation of a few native reflexes inherited by all the members of the species. Like any other animal, man starts life with a limited equipment of unlearned reaction-patterns to external stimuli; and upon these are grafted an immense number of other behaviour-patterns, which make up his learned equipment. To explain the activation of reaction-patterns by stimuli other than those which originally alone called them into activity, the behaviourist uses the principle of the conditioned reflex. Experiments have shown that a stimulus that is incapable of provoking a given reaction will, after presentation together with a connate stimulus to that reaction, evoke it. Thus Pavlov induced salivation in dogs as a reaction to the ringing of a bell, after the bell had been rung a number of times in connection with the presentation of food. Watson, again, showed that fear-reactions, originally provoked in very young children only by startling stimuli, such as loud noise or loss of support, could be associated with the sight of objects with regard to which the child had previously exhibited no signs of fear. A dog, in which the infant had before only shown interest, afterwards provoked fear-behaviour if it had been seen at the same time that the child had been frightened by a violent noise. Similarly, rage and love reactions, naturally provoked by a limited range of definite stimuli, could be " conditioned " to others. Moreover, just as the connate connections admitted of a fairly wide range of stimulus (*e.g.*, *any* loud noise) in provoking appropriate responses, so the conditioned reactions, it was found, spread also to stimuli that only resembled the one to which they had actually been conditioned (*e.g.*, the child would not only fear a dog, but anything *like* a dog, as, for instance, a teddy bear, or even a bit of fur or cloth). This looks like association by similarity, but in fact it can be reduced to contiguous association. On the basis of associative attachment, or " conditioning," and substitution of stimuli, together with alteration in the character of the response, behaviouristic psychology was erected, but on a physiological rather than a psychological foundation. It is a system strongly reminiscent of that of Hartley. The original endowment of man is a group of physiological reaction-mechanisms of a relatively simple kind. All complex behaviour is explained by environmental conditioning, which results in the formation (and re-formation) of habits as physiological as the inherited mechanisms themselves. The concept of instinct,

accordingly, is not needed to explain behaviour; neither is the concept of consciousness nor thought. For thought also is only a conditioned reaction to external stimuli on a par with any other. It consists in feeble movements of the organs of articulation (inner or sub-vocal speech) which have become substituted for the gross movements of limbs and body that were originally evoked by the same stimuli. The evidence upon which behaviourism is based is of a conative, or emotional, order rather than cognitive; and the theory ends in excluding thought as an interesting or useful topic for psychological investigation, and denying to consciousness any effective part in the determination of behaviour. It may therefore seem out of place to consider behaviourism in this section, except as an instance of refusing to allow mental processes any right of citizenship in psychology. Behaviourism is not at present maintained however, in its exclusive and rigid form, as outlined above. Though a considerable group of psychologists would still call themselves behaviourists, and make use of the conditioned reflex as the chief explanatory principle in psychology, there are few who altogether dispense with consciousness, or employ the principle of stimulus and physiological response alone to explain behaviour. Both consciousness and thought have been reintroduced into more moderate Behaviourism. Though genetic and even dynamic as a theory, its single principle was not enough to embrace all the facts. It could not explain how new ideas, or new types of behaviour, could arise, except as mere rearrangements of old ones. Yet thought, in some of its operations, is creative; and some behaviour gives evidence of true originality. Behaviourism could not continue to maintain that thought is sub-vocal speech, for definite experimental evidence disproves the statement. While the general bias of Behaviourism, accordingly, is towards a physiological explanation of mental events, its original formulation has been greatly modified. There were, however, aspects of permanent value even in the original statement of the doctrine. It was a protest against the merely structural view of consciousness to which pure introspection had led. It emphasised the importance of an objective examination of behaviour as functional. It introduced the principle of conditioning and transfer into general psychology in connection with behaviour, and not merely as a mode of association of inert ideas; and thus indirectly paved the way for a return to the dynamic conception of consciousness. Finally, though failing to account for purpose and volition as human experiences, its aim of determining behaviour on morally and socially desirable lines by the practical use of conditioned reflexes—its very name *Behaviourism*—suggested the lines upon which all along psychology had been developing; *i.e.*, as the science of the principles of behaviour, by the application of which conduct might be directed and guided.

FORMALISM OR "GESTALT"

A second type of contemporary psychology, definitely in revolt against the atomistic and structuralistic conception of consciousness, has developed from the fundamental postulate that there is more in any psychological whole than the mere sum of its parts. In germ this system, commonly known as *Gestaltpsychologie*, or Formalism, may be traced back

to Wundt's (b. 1832) doctrine of mental creative synthesis; which is illustrated, among others, by the fact that though one can analyse a tonal clang into a fundamental tone with its overtones, the mere putting of these together again does not result in the clang. There is more in the latter than the sum of the tonal components. This view was developed by the Austrian psychologists, particularly Ehrenfels, who noted that a large number of sensory qualities belong to perceived wholes as such, and cannot be derived from the isolated sensations which enter into them. Thus "triangular," "round," "square," are properties of triangles, circles, squares, as mentally apprehended wholes, and add something to the elementary sensations supposed to constitute them. This "something" is evidently relational in character, as appears even more evidently if we consider a melody, which is not a mere collection of notes, but of notes related in a definite manner. Thus, though every single note is altered when the melody is transposed, the tune itself remains unchanged because of the "form quality" constituting it. This fruitful conception, originally worked out with regard to shapes (hence *Gestalt*=German for *shape*, or *form*), was extended to wholes of other kinds; and attention was focussed upon the dynamic mental process by which wholes come to be formed and isolated. The most recent, and perhaps best-known, developments of Formalism, however, are due to the work of a group of German psychologists (Wertheimer, Köhler and Koffka) who have extended the theory to cover conscious processes other than perception. They have brought forward experimental evidence in its support, and have applied it in the interpretation of animal and child psychology with very considerable success. Meanwhile, the Austrian school has not been idle either in experiment or development of theory; and, though there are divergences of opinion between the two schools with regard to the nature of the mental processes involved in the creation of form, both are in general fundamental agreement. Though the Austrian school antedates that of Berlin, the latter considers that the principles of Formalism were first stated by Wertheimer as the result of his research into the problem of movement apparently perceived when the stimuli presented are not themselves moving. The problem is that of the zoetrope or kinematograph, in which the eye is stimulated by successive pictures representing stationary, but different, phases of moving objects, and combines these pictures into the representation of apparently continuous movement. Wertheimer rightly explained the apparent movement as something over and above the impressions actually made by the isolated stimuli, and attributed it to a configurational or formalising process as immediate as the sensing of the elements which are perceived as already in relation. There are not two processes, first sensing and then shaping, as the Austrians hold, in the perception of wholes, but only one. With this modification, the conception of form or shape was at once extended to cover all the operations of sensory perception, as well as of thought. Connected with the psychological doctrine of mentally configured wholes, which has met with wide acceptance, is a physiological one: namely, that there exist connate configurational patterns in the nervous system, which are correlated with the mental wholes, and correspond to objectively configured wholes in the environment. These physiological patterns are held to function as

response mechanisms. Though based on speculation rather than physiological evidence, this is a far-reaching extension of psychological theory to physiology, and even to physics. Other than psychological aspects of Formalism, however, need not detain us here. Having shown that wholes are, in fact, more than the sum of their parts, it was necessary to complete the doctrine by showing that they are original, in the sense that no other mental items than structured wholes are directly known, and that it is to these we react. Instead of elementary sensations, or the " buzzing, booming confusion " of sensations held by James to be the ground from which consciousness develops, Formalists teach that mental development starts with structures or wholes, however primitive their character may be. To substantiate this genetically, they point to observations and experiments made upon child and animal behaviour. Primitive and incomplex wholes become more complex and fully structurated in virtue of the *Principle of Precision*, whereby they " tend to become as perfect as prevailing conditions permit." This not only accounts for our tendency to perceive, say, an incompletely drawn triangle as a complete triangle, but also shows how learning takes place in the animal, child and adult by increasing structuration of wholes and the inclusion of new elements within them. The old view that learning comes about by slow associative processes of trial and error, during which pleasurable or successful reactions are stamped in so as to become habits, while unsuccessful or painful ones become eliminated, is supplanted in Formalism by a doctrine of insightful learning. New wholes are suddenly apprehended; a new structuration occurs, or a new element is incorporated into the situation, with consequent changes in reaction. Many examples of the working of the Principle of Precision are given in Formalist literature. Köhler's observation of the behaviour of his chimpanzees is classic. Faced with problem-situations in the attainment of goals (*e.g.*, food), they overcame the difficulties by behaviour which displayed insight. To cite examples, one gifted ape, whose fruit was too far from the bars of his cage to draw in with a short bamboo pole, happened by chance to fix two bamboos together, and used the artificially made " tool " to fish the food into the cage. Once he had thus chanced upon the solution, he perceived the means towards the goal insightfully, and thereafter was able to fit bamboo poles together to gain his ends. His reaction to the situation had altered. In the Formalist explanation this means that the whole situation (cage, food, sticks, etc.) had become enriched by the integration of the two-poles-joined-together with the rest. Indeed, he had already perceived this enriched whole when he unsuccessfully tried to push one stick in line with the other towards the fruit. The sticks were not joined together, but the solution was indicated. Though the ape stumbled on his solution by chance, he at once perceived the tool appropriate to the situation. Learning in this respect was complete. Other instances are given to show that insightful solution does not always arise by chance, but by scrutiny of relations. And several examples are advanced, in which the difficulty of breaking up one whole, and perceiving its parts as integrated in another whole, is brought out. Thus one ape, able to use a box to reach fruit hanging high up in the cage, did not make use of it when another ape was lying upon it. It was then a " resting place," not a " means for reaching fruit." When her companion had fallen

off the box, however, she at once grasped it, carried it under the goal, mounted, and seized the fruit. Köhler notes also, in illustration of the same point, that the following situation proved very difficult. The fruit lay outside the cage; there was no stick in sight; but a dried tree with branches stood at the back of the cage. The difficulty lay in "releasing" a part (branch) from one whole (tree), and transferring it into another configuration. While it was in the configuration "tree," it could not be apprehended as a tool. A similar account is given of learning in human beings. A child comes to dread the fire, not by association of painful experience with the visual appearance of fire, but because the relatively simple fire-whole suddenly becomes more completely structured and meaningful, calling for a new reaction. Meaning thus grows in more primitive, but already meaningful, wholes by further structuration. It is not created by experience, but merely transformed by it. Rignano has pointed out that serious difficulties beset this account of meaning and its growth. He stresses the part played by our emotional attitudes in the determination of what shall be object-wholes for us, and of our conative dispositions in the fixing of their meaning. A chair is a unitary whole to sit on, a part of a drawing-room set, or the like. And he insists upon the share that experience has in contributing both to wholes and their meanings by way of association. It seems to be clear that the concept of association cannot yet be dispensed with in psychology, however much Formalism has contributed to the advance of the science. The greatest contribution of *Gestalt* to contemporary psychology, however, is undoubtedly its vigorous protest, supported by a wealth of comparative and experimental evidence, against the insufficiency of associationism. Not only are mental objects originally perceived as meaningful wholes which grow by structuration, but they are wholes perceived in relation to goals to be attained, and so explain behaviour. Thus purpose is implied from the outset of mental life. Although Formalists have almost entirely neglected detailed study of feelings, emotions and will-acts, in this respect their theory will fit in with hormic psychology, to which it makes serious contributions on the cognitive side. Nevertheless, though implying conative activity throughout, and emphasising cognitive activity in the tendency to perfect configurational wholes and to enrich them with meaning, it stops short of any real mental creativity, either in thought or behaviour, which might take us beyond the sphere of sensory experience. Unlike the behaviourist principle, that of Formalism would seem to have little practical application to the development of character and the guidance of conduct. Though it is no doubt true that "the larger the wholes and the greater their unity, articulation, and meaning . . . the more personality will they express," the claim that an explanation of personal development is ultimately given by means of the universal law of *Gestalt* alone needs further substantiation; for it would appear that subsidiary principles also are required to construct a complete psychology of personality.

PSYCHO-ANALYSIS

Since the third type of contemporary psychology has an article to itself in this volume, it will only be necessary to refer to it very briefly.

Psycho-analysis, popularly perhaps the best known of current psychological systems, embraces a number of theories which have grown up around a method of investigating and treating mental disorder. It originated in the practice of hypnosis, during which it was found possible to bring to light the original occasions of certain pathological derangements in neurotic patients, and so to cure them. It was subsequently discovered that the hypnotic state was not necessary in order to secure curative results. Emotionally charged memories, though normally forgotten, could be recovered by appropriate treatment during a state of ordinary relaxation; and discharge, or working off, of the emotion then effected a cure. The point of departure for the analysis was found in the dreams of the patients. An elaborate theory grew up around these observations; and it has been extended from pathology to cover the psychology of everyday life. In the first place, the release of emotional tension of which the patient was wholly unconscious pointed to an unconscious, yet active, region of mind which influenced both consciousness and behaviour. This point became of capital importance in the theory. In the second place, great resistance was frequently encountered in carrying out the analytical technique; a fact which led to the formulation of the theory of "censorship." The conception is that of an active, repressive factor tending to secure the maintenance of the unconscious in its unconscious state. An indication of the functioning of the same mechanism was also found in the distorted forms of dreams; which were interpreted on good evidence as disguised manifestations of unconscious wishes. According to the view taken with respect to the inheritance of acquired characteristics, the unconscious is regarded as entirely individual or partly racial in origin; and the censorship, once conceived as the result of conscious social and moral repression, is now, at least in part, held to be an integral force of the unconscious mind itself. Theoretically systematised by Freud, psycho-analytic doctrine is presented as a mechanistic determinism on purely naturalistic lines. Conscious events are determined by unconscious ones which never may, or never can, come to awareness, and yet are psychical activities. Personality is rooted in the unconscious rather than in the conscious mind. And, though full use is made of the principle of association to explain the derivation and transference of forms of behaviour and thought from their unconscious motives, the fundamental explanatory principle of the system is that of the dynamic nature of the unconscious. Whether this is the drive of sex or the will to power, whether it is unique or manifold, differs according to the interpretation of different authors. But all alike definitely infer from the empirical evidence the two capital points of mental activity and the extension of this beyond the sphere of awareness. While Formalism, dispensing with association, provides the mental wholes grasped by the mind, Psycho-analysis, in common with Hormic psychology, indicates the activities making use of them.

The three contemporary psychological systems just considered are not, in fact, exclusive, but are mutually supplementary. All are based upon empirical observations, and are typically dynamic. All are concerned with the explanation of behaviour. But whereas one finds this in organic mechanisms and their conditioning without recourse to mind, another discovers it in the integration of conscious "configurations" and growth

of meaning, and the third in the profound depths of the unconscious. Each view has contributed to the development of current psychology. Native reaction-patterns together with the alterations wrought in them by conditioning; the conception of active configuration in percept and memory, as well as in the behaviour to which these give rise; the extension of the essential character of consciousness to the unconscious—all these have been incorporated into psychological theory, or at least have profoundly modified the outlook of the present day.

THE "TWO FACTOR" THEORY

A fourth system, incorporating the vital parts of the foregoing, has recently been developed within the field of experimental psychology. During the past twenty-five years, psychologists the world over have been investigating so-called "intelligence" and devising means for its measurement. Obviously, there can be no direct measure of such a mental function; but the accuracy and speed with which a person's mind works in performing intellectual tasks can be estimated from his output. Even then there is no natural unit of measurement; it is possible only to calculate norms, with their probable errors, from samples of the population, and to compare the performances of individuals with the norm. In this way a "mental age" can be assigned to them, which may or may not correspond with their real age. Original work in this field was done by Binet, who constructed "intelligence" tests to be administered to individuals (children) singly. Later, group tests were devised, by which large numbers might be tested at the same time. There was, and still is, much controversy in regard to the nature of "intelligence"; but statistical considerations have led to almost unanimous acceptance of the view advanced by Spearman, that whatever shows itself in intelligent behaviour, and is measured by the tests, consists of two factors, the one ("g") a general mental ability involved in all the tests, and the other a specific ability which differs according to the character of the particular test employed. To illustrate by a rough example, we might say that there is a common general factor of consciousness both in seeing and hearing, but a specific factor (eye or ear) involved in each performance. Using a large battery of varied tests, the specific factors tend to cancel one another, and a relatively pure measure of "g" may be obtained. Experimental and analytic work has shown that some tests are more "saturated" with "g" than others; and that it is best conceived as pure mental energy working through different engines. What is it that characterises individuals who are gifted with general mental ability? The results of an immense amount of mental testing, running into millions of cases, show that they score highly in tests which chiefly involve three mental processes, deriving from three basic laws or principles of original cognition. They score in the tests (1) when the mental items involved come quickly and clearly to awareness, (2) when relations of various kinds between the items are quickly and clearly noticed, and (3) when, such relations being applied to such items, correlated items rise quickly, clearly and accurately before the mind. All these processes are characterised by insight; and they are exclusively the ways in which new knowledge, as distinct

from remembered or recalled knowledge, arises.[1] The principles accounting for these processes have been termed by Spearman, who formulated them as providing a complete account of the genesis of knowledge, *Principles of Noegenesis*. They are expressed as follows. (1) " Any lived experience tends to evoke immediately a knowing of its characters and experiencer." (2) " The mentally presenting of any two or more characters tends to evoke immediately a knowing of relation between them." (3) " The presenting of any character together with any relation tends to evoke immediately a knowing of the correlative character." Briefly, knowledge arises from experience; relations are grasped within knowledge; the application of relations to items of knowledge generates new items. Of these principles the last is astonishingly fruitful. It can take us in thought beyond any previous experience, even beyond all possible experience. To it are due scientific hypothesis and invention, as for instance the transfer of the perceived relation of steam and kettle-lid to the conceived situation of steam in a boiler in order to work an engine. It accounts for artistic creation in every sphere of art, and even for concepts which have never entered into experience in any way, such as those of infinity, eternity or God. While all the noegenetic processes are expressions of mental activity and even creativity, the third thus expresses creativity in an especial manner. But the noegenetic principles, though accounting for the origin of knowledge, do not cover the entire cognitive field. And it is the claim of the system we are examining that it is explanatory of all cognitive process. The noegenetic principles do not explain remembering or forgetting, variations in clearness of mental items, differences in original mental endowment, or power of controlling thought. Five further principles of a quantitative kind are accordingly necessary to complete the account of cognition. The first is one of constancy; every mind maintains a total simultaneous output, which may vary in quality but tends to be constant in quantity. This principle, illustrated by the limitation of mental span, restates the two-factor doctrine. An individual's general mental energy tends to be constant, but is available for different operations. Next comes the principle of retentivity, manifested both in inertia and facilitation of mental processes, under which head the old law of association is included. Mental items experienced together tend to be retained and experienced together again. The reverse of this is the principle of fatigue, which summarises the tendency of a mentally experienced event not to occur again. These two principles together express the summated effect of earlier upon later experience. The fourth principle is that of conative control. By willing and striving we can alter the direction and intensity of our knowing. Lastly, there is the principle of primordial potencies, indicating those original individual differences which are the ultimate personal conditions of the functioning of the others. These five quantitative principles, together with the noegenetic laws, form a framework of explanation into which it has been found possible to fit every

[1] The following test illustrates all three processes: " 'Complete the sentence ' Smoke is to fire as finger-print is to . . .' " No answer can be given unless the meanings of " smoke," and " fire " and " finger-print " are grasped, the relation of " sign " obtaining between " smoke " and " fire " perceived, and that relation applied to " finger-print ", to generate the item required.

variety of cognitive process hitherto examined. It must be noted that the noegenetic, or qualitative, principles are stated in a purely psychological way without reference to physiology, whereas the quantitative principles, while capable of similar statement, are given physiological consideration as well. In respect of the three processes in which experience, relations and correlates become known, the psycho-physical connection is utterly obscure, and no help is afforded by physiology in their explanation. This is not so with regard to the quantitative principles, except in one case. Though they express psychological tendencies, physiology is able to throw some light upon them. The two aspects should, no doubt, be kept separate; but neither science can here afford to ignore the other. Most interesting in this connection is the recent work of Lashley, which indicates a general energy resident in the nervous system and available for use in various directions. This is an exact physiological parallel of the psychological doctrine of the two factors. The one exception, emphasised by Spearman, is the principle of conative control. Recent experimental investigation of will-acts (*see below*) supports his view. It points to a distinction between conation and volition. Now, the dependence of a conation (say, to move a limb) upon a will-act to do so is as utterly obscure as the passage of experience into knowledge; and physiology has no useful explanatory suggestion to offer the psychologist in the matter. The problem, like that of the origin of knowledge, remains a purely psychological one. Indeed, this was already indicated in the statement of the first noegenetic principle, where the experiencing subject is asserted to be one of the objects of which we tend to become aware. This subject is very intimately connected with his will-acts which according to the evidence appear to be absolutely effortless precursors of conations of a physiological as well as a psychological character. We have, then, in this system a general mental energy presented which, at least to some extent, can be directed at will from one kind of operation to another. The well-investigated phenomena of inertia, mental lag or perseveration, and of oscillation (or "fluctuation of attention"), are aspects of this same energy. It works in various engines to produce different cognitive results. The engines, in Spearman's view, are provided by the nervous system, so far as its function is localised; and this, coupled with his doctrine of the nature of noegenetic process, leads him to suggest that the chief purposes subserved by cerebral localisation are sensation, movement and retention. The roots of the mind ramify in physiology; its branches, flowers and fruits, so far as we at present know, have no physiological implications. There remains one point to complete the picture. In this presentation of psychology we have energy and engines; but there is also an engineer. The investigation of the former will indicate the conception we are to form of the latter; which, in the writer's judgement, is the keystone of a personalistic psychology.

THE DEVELOPMENT OF CONTEMPORARY PSYCHOLOGY

The contemporary systems of psychology, which have so far been considered, are scientific in the strict sense of the word. They do not attempt ultimate, but only proximate explanations of phenomena; they

simply investigate behaviour, or the mental processes underlying behaviour. Even on the cognitive side, however, many experimental data have been gleaned for deeper philosophical consideration. The essentially dynamic character of mental process, activity in the formation and completion of configurated wholes, activity in the region of the unconscious, creativeness in the operation of noegenetic laws, the central position of the self in the psychological synthesis : all these positions, already gained in science, point to the lines upon which a philosophy of human personality must proceed. In this we shall be reminded of much ancient speculation. For the pendulum, heavily weighted now with empirical and experimental data, is swinging backward again in contemporary thought from materialistic and physiological explanations of mental phenomena to spiritualistic and purely psychological ones. We can trace an ascending spiral on the record of psychological history ; and at each higher point in the curve the restatement of the old animistic doctrine takes on a more refined and substantiated form. To-day epiphenomenalism (the view that mind is a by-product of matter) need hardly be taken seriously. The issue is between parallelism of and interaction between mind and body ; and contemporary psychologists appear to be about equally divided upon that issue.

THE WILL

This consideration leads us directly to the topic of conation, or mind in its aspect of active willing and striving. Here again contemporary schools have arisen as protests against associationism, structuralism and phenomenalism. Already, as far back as Maine de Biran, a theoretical doctrine was advanced to account for the origin of habit, will and consciousness of self in a genetic manner. It was an attempt to explain volitional consciousness as consciousness of self upon empirical lines, which would cut across the mechanistic conception of the followers of Hume. Biran held that the self was essentially an experiencing activity of a spiritual kind ; and he explained how it becomes aware of itself as such. In the first instance, certain reflex activities are mechanically determined by external stimuli. But, on repetition of stimulation, experience divides into two orders, that of active self and that of object to which the self reacts. It is self as will, especially when effort is experienced in the exercise of its activity upon objects, which is revealed to us. William James also stresses the feeling of effort in " the slow dead heave of the will," as well as the *fiat* (" let it be so ") which distinguishes the highest form of will-acts from all other processes of consciousness. Of recent years, however, a great deal of experimental work has been carried out upon problems connected with willing and striving, the results of which fit in well with the findings of Hormic psychology and psycho-analytic theory. This work has mainly followed the two methods of controlled introspection and of estimates. Beginning with researches upon choice carried out in the laboratory of Wundt, the first method was perfected, both with regard to choice of problems for attack and in technique, by a group of workers largely influenced by Külpe. Notable among these are Ach and Michotte. The first named, investigating the resolutions taken by his subjects to

carry out prescribed mental tasks, found that the true will-act occurs at the moment of resolution, and not in the subsequent performance. The latter, he found, was conditioned by the previous volition, and took place in virtue of what he called a "determining tendency" brought about by it. These volitional determining tendencies are assimilable to native, or instinctive, dispositions in that they may operate without further conscious guidance or control. Ach was able to induce very strong resolutions in the course of his experiments, which aimed at measuring the strength of the will when pitted against strong associative tendencies. His subjects were required, say, to find rhymes to syllables which had so been learned over and over again with others that, when re-presented, there was an almost irresistible tendency to react with the associated syllables. What he really measured, if anything, was not the strength of will-acts, but that of the associative against the determining tendency. Nevertheless, his work shows that conative activities are called into being by the will. Further experimental investigation has emphasised the distinction between conation and volition, and shown that, while great effort may be involved and experienced in striving, acts of will may be entirely effortless and yet effective. Ach's fine introspective analyses further prove that the experience of resolution is in an intimate way bound up with the lived experience of the self; which can be characterised only by the description "*I* truly will." Thus volition, in its form of resolution, is a peculiarly impressive manifestation of self-activity. Here are gains for psychology of the greatest importance; the introspective isolation of will-acts, their clear distinction from feelings of effort, and the definite relating of volitional process to the active self.

Similar results were obtained by Michotte, who investigated the process of voluntary choice. In his experiments the subjects were required to choose, for good reasons, between alternative arithmetical operations to be carried out, between different combinations in pairs of pleasant and unpleasant liquids, one of which had to be tasted, and the like. As in Ach's experiments, it was found that the choice-process developed under the influence of volitional determining tendencies set up by the previous acceptance of the instruction (resolution to choose). The choices themselves were capable of analysis on broad lines. Though exceedingly complicated processes, fairly definite phases were distinguishable in them, such as the perception of the alternatives, evolution and deliberation of motives, development of feelings, and finally consent to, or designation of, the alternative chosen. The subjects distinguished two typical kinds of choice, cold and lively, and it was found that the "cold choices" were the more voluntary of the two. But these were precisely those choices in which the feeling of effort was least apparent; and the introspections to this effect were borne out by the objective controls (breathing records, etc.), which showed "lively choices" to be accompanied by considerable physiological disturbance. This observation further emphasises the distinction between volition and conation, to which reference has been made. As has already been stated, the whole process of choice may take place automatically in virtue of the previous resolution to choose; but there occurred many cases in which will intervened during the choice itself. When this happened, the experience of self-activity, as in the case

of Ach's resolutions, was reduplicated in what Michotte terms "consciousness of action." This is an important result of Michotte's investigation; for it points again to the phenomenal appearance of self in consciousness, an experience sharply differentiated from the consciousness of effort which may accompany it. Once more self, as will, is indicated as an experience entirely distinct from feelings of physiological origin. Experiments similar to those of Ach and Michotte have been carried out in the laboratory of the present writer, with results which confirm their conclusions; and correlation of the introspective reports with psycho-galvanometric records taken during the researches corroborates the distinction, exceedingly important for theory, between volition and conation. Where effort is reported, the galvanometer indicates bodily change.

Research of another kind was carried out by Webb, who used the method of estimates. His problem was to discover what character-qualities tend to be found together in individuals; and to this end he had a large number of persons ranked in order, by competent judges, in respect of different character-qualities which they displayed. Only those rankings were used in his conclusions when several independent judges agreed in their estimates closely enough to obtain a good "reliability coefficient" (*i.e.*, when high agreement obtained between the rankings). Having obtained his data in this way, Webb calculated statistically the tendency of certain traits of character and intelligence to be shown in the same individuals. He found that the moral and social qualities of perseverance in face of obstacles, kindness on principle, trustworthiness, and conscientiousness are qualities of persons whose intelligence is profound rather than quick; whereas readiness to become angry, eagerness for admiration, and bodily activity in pursuit of pleasure, characterise those persons whose intelligence is quick but not profound. He thus showed that a general will-factor exists which reveals itself in character; and he concludes that consistency in conduct results from deliberate willing. Webb's data might have been interpreted in another way, as pointing to the general factor of perseveration already established by previous work. Stability in character might not be due to will, but to mental inertia. His conclusion, however, is supported by further investigations made by Lankes, who used the methods both of experiment and estimates. Having obtained rankings for character-qualities similar to Webb's, he also tested for perseveration, and correlated his results. The event proved that consistency of conduct, or perseverance, is not perseveration. The latter is a native character of the nervous system; the former the result of a person's own effort and will. Lankes sums up by saying "the self, with persons used to act . . . from higher motives of reason and principle, not according to merely natural bent and inclination . . . can modify, and directly counteract, its own nervous system and its innate tendency towards perseveration or the opposite."

It will readily be seen how the two lines of attack upon the problem of will lead to similar and mutually supplementary results. A large field is opened for further exploration; but already the gain is recorded of an aspect of self which is fundamental. It is a self which enters experience as an essentially active and controlling reality, largely directing its own

behaviour, and irreducible to a mechanical system of sensations or neural processes.

FEELING AND EMOTION

If the field for work upon the will is large, that for the investigation of feeling and emotion is still larger. The psychology of emotion is in a far less advanced state than that either of cognition or conation. To begin with, there is a difficulty with regard to the meaning of the term emotion itself. Sometimes it signifies conation, sometimes feeling, sometimes a blend of both. Until more exact analysis is forthcoming, there is bound to be confusion. From very early times two chief views have claimed adherents; one, that emotion is a mental state which leads to conation, the other that bodily conation is experienced as emotion. The two views are contrasted by James, who advanced the latter, in a well-known passage:—" Common sense says, we lose our fortune, are sorry and weep; we meet a bear, are frightened and run . . . the more rational statement is that we feel sorry because we cry . . . afraid because we tremble." James picturesquely over-emphasises the rôle of the skeletal muscles in emotion; but visceral and glandular changes must principally be taken into account. The elements of both views are implicit already in Descartes' doctrine of the passions of the soul. Like all conscious processes, emotions are thoughts, not bodily states. None the less, they are perceptions of changes occurring in the body. Physical impressions conveyed to the brain bring about bodily changes which result in seeking, avoiding or defence reactions. In the lower animals this is all that happens. But in man the mind perceives the bodily " commotion," and so experiences " passion." Emotion is thus a conative adjustment of the body perceived by the mind. But it is more than this. It is also an incentive to acts of will, which in turn influence movements of the body. It is accordingly not merely, as for James, a mass of bodily sensation, but a dynamic mental state lying midway between knowing and doing. Interesting in this connection is Wundt's emotional theory of will. Elementary feeling-qualities carried by sensations become fused in higher and higher " emotions " which develop in regular sequences, and usually lead to acts of will. These latter consist in those emotional sequences which end in a feeling of resolution and lead to overt action. Since consciously willed acts tend to become mechanised and unconscious in us, Wundt extends the concept of will to cover all purposeful action whatever which satisfies biological needs. Thus his emotional theory of volition includes both impulsive and reflex acts, which genetically once expressed conscious wants of the organism, but now simply connote a typically emotional sequence in which the feeling of resolution is absent. Will as emotion is thus an entirely general and fundamental character of mind. A similar rôle assigned to emotion will be recalled from what has been said of Behaviourism, in which theory both natural and acquired reaction-patterns are regarded as activated by external stimuli. Here the conative aspect of emotion is stressed to the exclusion of the feeling aspect; and will is reduced to mere physiological striving. In sharp contrast with this last view is that of the Hormic psychology developed by McDougall. Here emotion is made the central part of the instinctive process, which is initiated by perception of

connately adapted stimuli and issues in definite conative activities leading to observable behaviour. Both on the perceptual and the conative side, modifications may occur which explain the complexities of acquired forms of behaviour; but the emotional core of instinctive and acquired behaviour is fundamental in the theory. This view leads to the exceedingly important conclusion that emotion is the clue to behaviour, as it indicates the natural springs of action. By the play of cognitive process upon these through the emotions, character may be built up and conduct may to a large extent be guided; and it is by stimulating the natural needs and wants of human beings in this way that the success of applied psychology in all its branches depends. The investigation of the physiological changes connected with emotion, though of less psychological interest, has proceeded apace. Since the time of Lotze, who was one of the first to examine changes in facial expression, bodily posture, alterations in breathing and pulse, under emotional stress, many investigations of this problem have been undertaken. In general, it may be said that these point to the autonomic nervous system, the lower centres (thalamus and basal ganglia) of the brain, and the endocrine, or ductless, glands, as more particularly concerned in emotional reactions. The work of Langley, Head and Sherrington on neural processes, and that of Brown-Séquard, Cannon and Crile on the secretions of the ductless glands, may be cited in support. Especially interesting is Cannon's investigation of the function of the adrenal glands. He showed that fear and rage excited in animals provoked the secretion of adrenalin, with consequent increase in blood pressure, liberation of glycogen from the liver, and heightened stimulation of striped, or so-called "voluntary," muscles. This indicates a conative set in the animal, fitting it to react with greater vigour to the object which provokes fear or rage. But the question still remains open whether these changes are the cause or the effect of the mental state. One indication of a possible answer lies in the temporal sequence of events. Some of the physiological changes are very slow, and all require time. In experiments upon will-acts, using the psycho-galvanometer as control, the mental attitude seems certainly to precede the physiological one as indicated by the deflections of the needle. This would appear to show that the conative part of the response takes place definitely before the experience of the "emotion." Here, again, there appears to be evidence of the essential activity of mind, as already instanced in the creative activities of thought and the controlling aspects of conation.

PERSONALISM

Before passing on to consider the applications of psychology to practical life, it will be in place here to suggest, in the light of the foregoing analyses, a view which has been shaping itself in contemporary thought with regard to the nature of the feeling, thinking and willing subject. Those psychologists who are not so "departmentalised" as to exclude consideration of the deeper problems of their science, are coming to realise that analysis, though a useful and even necessary method, breaks up in thought what is in fact indivisible. The conception of consciousness as a mosaic of sensations, or products of mental chemistry, has been

abandoned. Functional psychology has been substituted for structuralism. Since Herbart, polemic has waged fiercely against the theory of faculties (intellect, memory, imagination, etc.) as unitary functions, until definite experimental evidence has been adduced that no such functions exist. The notion of man as a collection of separable instincts, of personality as the integration of native and acquired reaction-patterns, or modes of behaviour, is beginning to lose favour. In place of these abstract products of analysis, stress is laid upon the undivided totality of the person as an organic whole, all of whose reactions are purposive. This is personalistic psychology; and it has taken several forms. Most interesting is Stern's view that scientific psychology and personalism go together. For Stern, a " person " is a being which, in spite of the multiplicity of its parts, presents a real unity, having a character and value of its own. Thus, notwithstanding its many subordinate functions, a person is in fact a unitary and purposive self-activity. It is, however, psycho-physically neutral, lying beyond its physical and mental manifestations, either of which may be interpreted mechanistically or teleologically. For, in Stern's view, the antagonism between mechanism and teleology is reconciled in a teleo-mechanical parallelism. Moreover, a person's " disposition " is a single inner factor which co-operates with external factors, and thus manifests itself in a series of single tendencies and characteristics. This doctrine is the philosophical basis of Stern's scientific treatment of individual differences; to which subject he has contributed experimental results of a very high order. While Stern's purposive self-activity is beyond its manifestation, other personalists maintain that it is actually lived and apprehended in self-experience. This is the conclusion of much experimental work by such investigators as Dürr, Katzaroff, Michotte and Ach, to some of which reference has been made above. As actually experienced, the self, according to Calkins, exhibits four principal characters. It is consciously self-identical; it is consciously unique, consciously related as ground to its own experience and also in many ways to its environment. These characters, together with that of its activity, provide a clue to the conception we should frame of it. Is it matter? Is it spirit? Is it a compound of both? Clearly it is not matter in the old sense in which matter was conceived as an inert substratum for quantities and qualities. Modern physics itself is abandoning that concept for one of energy, which it has borrowed from psychology. Clearly it is not matter in the sense of mere potency; for that is a contradiction of all experience. As clearly, it is not spirit in the sense that it exhibits no physical phenomena; otherwise there could be no communication between selves, nor interaction between a self and its environment. We are driven back upon psycho-physical interaction or parallelism, with an altered value put upon both the terms psychical and physical; for the reality lying behind physical phenomena, and the psychical as given in experience, appear to be assimilable in the form of energy directed towards ends, aimed at goals, one kind of which at least is evidently self-conscious. Whether this personalistic view be acceptable, or, as in other philosophical interpretations of the facts advanced by different schools of psychologists, pure spiritualism or pure materialism is to be preferred, one thing is pragmatically certain, since, in fact, it *works*. This is, that the discoveries of contemporary psychology

are applicable with advantage to the practical affairs of everyday life. The science is not only a theoretical, but also an applied one.

The principal directions in which psychology has already proved of value in application to practical problems are those of education, medicine and industry; though its applicability has proved to be possible in other spheres also, such as those of law, commerce and social organisation.

APPLIED PSYCHOLOGY: EDUCATION

During the modern period, at least as far back as Herbart, psychological knowledge has been employed in the service of education. The doctrine of apperceptive masses indicated lines upon which educational practice should proceed. The child should gradually and progressively be supplied with information which is easily assimilable to the background of knowledge already possessed. Moreover, in this process his own powers of observation should be trained; for information is not simply poured into his mind by the teacher, he must acquire it for himself. Pestalozzi and Froebel insisted on this aspect of training, not neglecting character-formation, the latter especially emphasising the value of vivid stimuli (colours, playthings, etc.) in attracting and securing attention. His theory of education by the play-method led to the institution of the kindergarten, and has further been developed in the Montessori system. But other problems demanded attention also. The discarding of the doctrine of faculties raised the question of the possibility of "transfer of training." Does training in one subject, or skill, facilitate the learning of another? Does learning Latin, say, make learning Greek easier? Or does practice in manipulation with one hand help in the acquisition of skill with the other? It was found that such facilitation only occurs when the several subjects or skills concerned are very similar in character; a fact which has largely influenced educational curricula. A like problem arose in respect of memory. Is this a unitary power, good or bad all round; or do people have good memories for some things and bad for others? Again, research has shown that "memory" consists in a number of memory-functions, and that the degree of functional unity is connected with the degree of likeness of the material remembered. Thus, though retentiveness varies from one individual to another, it is incapable of general training. On the other hand, work initiated by Ebbinghaus and prosecuted by a large number of investigators shows that there are advantageous methods of memorising and acquiring skills. In general, for example, learning by wholes is more economical than learning by parts; spaced-out learning is better than learning all at once. These conclusions also have been fruitful for educational practice. Even more important, however, has been the discovery of the possibility of measuring general mental ability, as well as certain special aptitudes, by the use of intelligence and other tests. This not only permits of children being graded for teaching appropriate to their mental age, but also gives indications of special abilities which would benefit by intensive training, or the lack of such abilities in children upon whom training would be wasted. On the character side, as contrasted with intelligence, much headway has also been made in applying psychological knowledge to problems of maladjusted, naughty or

troublesome children. Emotional and conative defects, lack of control, and wrongly formed habits are, to a large extent, amenable to treatment; and the multiplication of highly successful child-clinics for this purpose is evidence of the educational and re-educational value of applied psychology.

APPLIED PSYCHOLOGY: PSYCHOTHERAPY

This last consideration indicates a connection between educational psychology and psychotherapy. Just as maladjusted children can be successfully readjusted by psychological means, so many forms of neurosis yield to psychological treatment. From time immemorial psychology has in one way or other played its part in the practice of general medicine. Plato relates how Socrates described the cure of headache by suggestion, and the earliest records of Egyptian medicine show how psychological principles were used in effecting cures. Psychotherapy is to-day a recognised branch of the medical profession, specialising along definite lines in the treatment of functional, and sometimes organic, disease of mental origin. The chief methods in use are those of suggestion during hypnosis or in the hypnoidal state, psycho-analysis and re-education. By such means not only phobias (fears), compulsions (irresistible impulses), tremors, tics and morbid habits, such as alcoholism or drug-addiction, may be cured, but even serious physical conditions may be ameliorated. Apart from definite curative suggestions and catharsis, or mental purging, however, the influence of emotional states and conative attitudes upon physiological processes is well known; and the skilled practitioner draws upon general, as well as special, knowledge and technique in his therapeutic procedure.

APPLIED PSYCHOLOGY: INDUSTRY

Among the latest developments of applied psychology is that connected with industry. It has at length come to be realised that human beings, as well as machines and materials, are involved in production; and that individual differences are of the greatest importance in adapting people to the various avocations of industrial life. Some employments require much intelligence, others less. As we have seen, individuals may be tested for general mental ability and advised in respect of, or selected for, tasks which are suited to their capacity. Again, perseverative tendencies, which make for slowness in adaptability, would be a great handicap in some tasks, whereas a strong perseverator would perform others with ease and success. This general factor can also be tested, and advice given or selection made accordingly. Similarly, many special aptitudes which fit or disqualify people for particular forms of work can be investigated by testing. In this way, a fairly complete picture of the individual is reached, so far as possibilities of performance are concerned. There are some jobs in which he can never make good; in others he may prove a success. That he will not certainly be successful in these depends on other factors than general and special abilities of a cognitive or executive kind. Human beings are not machines, nor even intelligent machines. Their emotional and conative make-up must also be reckoned with. Their needs, desires

and feelings constitute a no less important consideration than their abilities in fitting them for different employments ; and individual differences in these respects also must be taken into account, not only in vocational guidance and selection, but in their subsequent occupational career as well. Here, again, psychology has much to offer to worker, employer, distributor, salesman and even consumer. Investigations have been carried out upon the best ways of performing different tasks, the introduction of rest-periods between spells of work, the lessening of the hours of the working day, the avoidance of fatigue and boredom, the provision of adequate incentives to arouse ambition, and the like ; and the results, when applied, have proved to be advantageous to all concerned. Greater production has been secured with less effort, fatigue and emotional disturbance. Though here, as elsewhere, psychological research and application have begun with problems of the head and hands rather than of the heart, an immense field is opened up for further work. Our increasing knowledge of will and character-qualities will be found as applicable to industrial conditions as our knowledge of intelligence and special aptitudes has already been ; and the legitimate needs and desires of human nature, even when they differ, will be taken into account in industrial organisation. An illustration may already be found in the psychology of advertising and salesmanship. Clearly these can be practically successful only so far as they are based upon knowledge of the desires and motives which lead people to purchase goods. It is not enough to catch attention by a striking poster or paragraph, and to hold it by repetition. A mere description of an article by a salesman will not sell it. The prospective purchaser must want to buy, or be made to want to buy, by an appeal to need or desire. He must be given a motive to purchase which will be sufficiently strong to sway him. The appeal through the eye or the ear is not so much to his judgement as to his feelings. By further extension of this principle, applied psychology can go far both in industry and commerce. It can reach to professions or callings of every kind. Indeed, there is no sphere of life that it cannot touch. For to control our own thoughts, feelings and actions, and to adapt ourselves to our place in the social organism, some understanding of human nature, as manifested in ourselves and in others, is required. We must know those points in which we are alike and those in which we differ. Most of us learn a little of that knowledge in a rough and ready way through experience of ourselves and others in our various social contacts. But a detailed and exact knowledge is only possible through scientific observation of the facts and their experimental investigation. We end with the definition with which we began. Psychology is the science which investigates behaviour in general, from the point of view of its mental implications, and with a view to its guidance and control.

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THEORIES OF PSYCHO-ANALYSIS

By

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SYNOPSIS

Psycho-analysis is a branch of psychological science which has attracted much attention in recent years. Starting as a method for treatment of nervous disease, it soon opened up new and important fields of psychological research, which had hitherto been inaccessible to orthodox psychology. Though many of its conclusions have been hotly contested, it has nevertheless exercised, both directly and indirectly, a very great influence on modern thought, so that some knowledge of the subject is indispensable to those who would view the chief tendencies of present-day culture in their proper background and perspective.

In the first section of the following Article will be found a brief treatment of the historical evolution of psycho-analysis; its origin in the pioneer work of Breuer and Freud, the remarkable series of discoveries to which it led in the hands of the latter investigator; the founding of the psycho-analytic movement, which has for many years possessed an international organisation; the divergent doctrines of Adler and of Jung, who, from being originally followers of Freud, eventually established separate schools of their own.

The second section gives a systematic account of the chief concepts of psycho-analytic science; the nature of the Unconscious, the functions of repression, the significance of sex, symbolism, conflict, neurosis and sublimation.

In the third section the development of mind is considered in the light of psycho-analysis. An endeavour is made to show how psycho-analysis can explain much, both of individual character and of human culture as a whole, on the basis of the mechanisms of displacement and sublimation. Consideration is also given to the startling new revelations of psycho-analysis concerning the foundations of our moral life—revelations which are likely to be even more far-reaching in their social influence than were the earlier discoveries concerning the importance of sex. Finally there is a brief indication of what would seem to be the general significance of psycho-analysis for the future of human life and human society.

THEORIES OF PSYCHO-ANALYSIS

I

THE NATURE OF PSYCHO-ANALYSIS

Meanings of the Term

Psycho-analysis is a term that has carried a number of meanings—some legitimate and others not—and in approaching the subject it is well to be clear as to the nature of these meanings. In its widest sense the term has sometimes been used to designate almost anything within the domain of psychology. This is a meaning that was due solely to the indiscretions of publishers and journalists, anxious to sell their books or to gain the attention of readers by reference to a doctrine which, because novel and startling, was supposed to have a popular appeal; it is a meaning which, fortunately and rightly, is seldom to be met with nowadays.

In a more restricted, but still misleadingly wide sense, the term is sometimes used to denote the work of a number of psychological schools, which had a common origin, but which have now drifted so widely apart that all members of these schools have recognised that it is highly inconvenient to employ a common designation; and where the schools concerned themselves agree that a distinction is desirable, it ill behoves others to confound this distinction by applying the term "psycho-analysis" indiscriminately to them all. The schools in question are three in number, and all three owe their origin to discoveries made by Professor Sigmund Freud of Vienna towards the end of the nineteenth century.

Except for one collaborator in the first stages, Freud worked practically alone, until early in the present century. But from 1902 onwards a small band of followers gathered round him, resulting in the first Psycho-analytic Congress in 1908 and the foundation of an International Psycho-analytical Association in 1910. Soon after this latter date, however, two prominent members of the school independently and gradually seceded from it, first by stressing certain particular aspects of psycho-analytic doctrine, then by raising objections to other well-established aspects of this doctrine, and finally by neglect or reinterpretation of these latter aspects on such a drastic scale as to make it very clear that such mutual understanding as is required for profitable co-operation was utterly impossible. These members were Alfred Adler and C. G Jung, who thenceforward became the leaders of the schools associated with their names—schools which have in recent years been known as those of Individual Psychology and Analytical Psychology respectively. Of these,

Adler's school has the closer organisation and the more coherent body of doctrine; and is, in consequence, more definitely associated with the title it has adopted. Jung's views, though perhaps less systematised (except as regards an elaborate doctrine concerning " psychological types ") and to a lesser extent adopted *en bloc* by a particular body of followers, have nevertheless exercised a wide influence, particularly in Switzerland (their native home), England and America. In what follows we shall have occasion to deal with particular characteristics of both schools. Meanwhile, what concerns us is the fact that the original school of Freud has persisted and has retained the title by which it has been known since the beginning. At the present day the term " psycho-analysis " is, among psychologists and physicians, almost without exception employed only in connection with this latter school. There can be no doubt that this usage is the correct one, whether we look at the matter from the point of view of historical continuity, of ethical justification or of scientific precision. It is in this sense therefore that we shall understand the term here.

But even from this relatively narrow point of view, " psycho-analysis " can mean several things, between which it is possible, at least in theory, to distinguish. In the first place it means a method—a method at once of psychological study and therapeutic practice. In the second place it means the facts discovered by this method. Thirdly it signifies the theories that have been propounded to explain and correlate these facts. Lastly it is used to designate the application of the psycho-analytic method, viewpoint and theory to facts obtained otherwise than by the direct observation of the individual—facts which, in actual practice, have been collected from very wide and varied fields.

In our exposition we shall study, first the method, and then the facts and theories. For the sake of brevity it will be necessary to describe the facts in conjunction with and in the light of the theories, and not—as would for strictly scientific purposes have been preferable—to explain in detail how the theories were devised to fit the facts. To adopt the latter course would necessitate a detailed treatment of the whole development of psycho-analysis—a task which is far beyond our present purpose.[1] The reader may rest assured however that, unless there is specific warning to the contrary, use will be made only of such theoretical constructions as have proved themselves of unmistakable utility and are generally accepted at the present day by all competent workers in the subject. In the course of our survey we shall have occasion to indicate from time to time some of the chief fields to which psycho-analysis has been applied, together with the general bearing of these applications, both upon psycho-analysis itself and upon our general conception of the human mind and human institutions. As befits the character of the present volume, emphasis will be laid throughout upon more general matters of psychological and sociological importance rather than upon the contributions of

psycho-analysis within the narrower field of medicine in which it took its origin.[1]

Development of Psycho-analysis

The history of psycho-analysis is usually taken to date from certain observations made by Josef Breuer of Vienna in the early eighties of last century. Whilst treating a remarkable case of hysteria he discovered that the many strange symptoms of the case had a meaning, in the sense that they referred to certain forgotten (but, at the time they occurred, highly emotional) past experiences of the subject—and furthermore that these experiences could be brought back into consciousness by suitable suggestions or communications in the hypnotic state, and that, when they were thus brought back, the symptoms vanished (at least temporarily) and a general alleviation of the patient's condition could be brought about. The fact that hysterical symptoms had a meaning and depended upon certain buried memories had already been made clear by Charcot and his pupil Janet in France, but the curative effect of the recovery of these memories in consciousness had never been clearly demonstrated, and Breuer's discovery seemed to open up new prospects for a psychical therapy that was not directly dependent upon the effects of suggestion. On returning from a period of study with Charcot in Paris, Freud joined forces with Breuer for a time and persuaded him to publish the material which he had begun to collect some ten years earlier. In 1893 was published the first joint paper of the two collaborators, to be followed in 1895 by a book entitled *Studies in Hysteria*, which constitutes the first great contribution to the literature of psycho-analysis. This book, which was based upon a number of penetrating clinical studies, contained the germ of psycho-analytic theory and the description of a method of treatment which is still applied in psycho-therapy, though it no longer forms part of the orthodox procedure of the psycho-analyst. This method consisted essentially in the recovery of pathogenic (*i.e.*, disease-producing) memories in the hypnotic state and (a point which, early in the work, showed itself to be of great importance) the re-experiencing in consciousness of the appropriate emotions. This re-experiencing or working-off of emotion was termed "abreaction," and the method itself was called the "cathartic" (purging or clearing) method, since the patient appeared to be purified and freed from disease-engendering material as a result of this procedure. The underlying concept thus revived the idea long ago expressed by Aristotle with regard to the function of tragedy, which, he held, brought about a healthful "purging" by intense arousal of the emotions of "pity" and "terror." Breuer soon gave up this line of work, to which he had indeed never brought the same interest as his younger colleague. Freud however,

continuing alone, soon modified the procedure and devised the psycho-analytic method proper, as it has continued until this day. Following the procedure of the French schools, the production of the hypnotic state of mind had hitherto been regarded as an indispensable condition of the treatment. Freud's great step was to abandon hypnosis and to find a new method that could take its place. He gave up hypnosis, in the first instance for practical reasons, because—like other investigators—he found it could not always be induced ; secondly, because the capricious and often incomprehensible results of hypnotic treatment displeased him as a scientist. He early obtained the impression that by the use of hypnotism certain difficulties or obstacles were evaded rather than overcome. This might in some cases be satisfactory, so far as immediate therapeutic effect was concerned ; but it was very dissatisfying from the point of view of medical and psychological science, which seeks, not only to cure, but to understand the principles of cure. It was clear, however, that ordinary procedures in the waking state were powerless to produce either understanding or alleviation of the patient's troubles. If these troubles had a mental origin and a meaning explicable in psychological terms—facts of which by this time Freud was fully assured—this origin and meaning appeared to be quite inaccessible to consciousness. Something in the structure of the mind seemed to bar the way to understanding. This barrier had somehow to be overcome, if the true nature of the symptoms was to be elucidated. It was to meet this difficulty that the psycho-analytic technique was gradually evolved. By a series of approximations, which we need not stop to detail here, Freud developed the procedure of free association, which has ever since remained the chief weapon of the psycho-analyst and the essential feature of the psycho-analytic method. This method consists in asking the patient to abandon all conscious control and direction of his thoughts and emotions and to say everything that comes into his mind without hindrance or criticism. Absurdly simple as this may sound, and simple as it is indeed in theory, it is yet very far from easy in practice. It constitutes a radical departure from the speech habits of everyday life, in which we are (with good reason) constantly controlling and adapting our words and thoughts in accordance with the circumstances of our environment. The nearest approach to such a mental attitude as is required is that of reverie or day-dreaming (a condition which we regard as quite peculiarly private and unsuitable for communication to others). Day-dreaming apart, there is always some task to accomplish, some line of thought to pursue, some special pre-determined chain of association to follow up—all of them circumstances in which, checking our tendency to "wander," we have constantly to keep attention upon the matter in hand. Even in social small talk, in which the logical sequence of ideas towards a goal gives place to a more unrestricted roaming along the chance paths of phantasy or recollection, there is always some limit to our freedom, necessitated by the claims of intellectual relevance, emotional congruity, or respect for the feelings and emotions of our fellows (as will be easily realised, if we imagine ourselves trying to find an opening for some favourite joke or story). In free association for purposes of psycho-analysis even this degree of control must be abandoned, the subject being instructed to say literally everything that occurs

to him, even though it appear inappropriate, senseless, shameful, disgusting or even rude—even though, in fact, the saying of it may involve a complete flouting of all the intellectual, moral, æsthetic and social canons of our thought and speech. Let the reader try the process for but a few minutes, and (if he is honest) he will rapidly convince himself that the procedure is a socially " impossible " one, and that he has already begun to edit or censor his associations, for the sake of his own feelings or those of his collaborator. Indeed even in the special conditions of the analyst's consulting-room the procedure is at best only partially adhered to; the process of analysis constantly meets with " resistances " which interrupt the flow of associations. Sometimes these resistances are of a conscious order and manifest themselves in a deliberate refusal to put into words some idea that has arisen. At the other extreme the patient is sometimes temporarily unable to progress, in spite of his most earnest conscious desire to do so. In such cases he may correctly assert that he " cannot think of anything," that his mind has " become a blank," except perhaps for some slight awareness of his immediate physical environment; or else, as if in flight from more important matters, he may prattle away about a quantity of insignificant events connected with his daily life. In either case a strong impression is received that there is some mental force impeding the entrance into consciousness of emotionally toned associations—a mental force that may sometimes appear in consciousness as disgust or embarrassment, or may sometimes itself remain unconscious. Here, as so often elsewhere in the sphere of mind, there is moreover a continuous gradation from the clearly conscious to the definitely unintrospectible, so that there arises a strong presumption in favour of the view that there exist unconscious resistances which in their general nature are somewhat similar to those that we observe in consciousness.

In spite of these formidable difficulties, however, the method soon showed itself to be capable of results of great psychological interest and therapeutic value. With its help a great fund of information concerning the nature of the mind and of mental development (normal and pathological) has been gradually accumulated. The most astonishing feature of the whole history of psycho-analysis is the vast field on which its discoveries have thrown a vivid light. Starting as a means of dealing with mental disorder, it soon revealed the fact that there was little essential difference between so-called " normal " and " abnormal," and that the processes shown to be at work in the patients' minds could be paralleled in almost every detail by those of healthy individuals; a slight alteration in the balance of forces could account for the whole difference between health and disease. Certain special types of mental process also began to be illumined by the new method. Dreams, for instance, which had long been a source of inspiration to the superstitious and of puzzlement to the learned, were shown to present many striking resemblances to the phenomena of the neuroses (or functional nervous disorders). Indeed the analysis of dreams soon began to play an important part in actual treatment. They constitute, as Freud has said, the *via regia* to the unconscious, and his advice to those who would obtain some insight into the real nature of psycho-analysis is that they should study their own dreams by the method of free association, starting from the various

items of the dream in turn, and noting the ideas and emotions that spontaneously arise when conscious control of thought is abandoned. The next matter to be investigated was that which was christened by Freud the "psychopathology of everyday life,"[1] the little forgettings, mistakes and slips of which we are all guilty at some time or other, and which he showed to be frequently determined by unconscious mechanisms of the same general nature as those which are responsible for the more permanent pathological disturbances that we term neurotic. The problems of wit and humour were then, in turn, attacked. Here, too, many of the same mental processes were shown to be at work, and psycho-analysis succeeded in throwing much additional light upon a field which had already been extensively cultivated by philosophers and psychologists. There followed excursions into the domains of art, literature, history and —most fruitful of all—anthropology. It is from the study of primitive ways of thought as embodied in the myths, beliefs, superstitions and practices of savage peoples or in the corresponding survivals among civilised races that there have come at once the most striking corroboration of psycho-analytic theory and the most far-reaching applications of the psycho-analytic method. The corroboration from this field (as from that of history) was particularly welcome, since there was here no possibility of the supposed discoveries of psycho-analysis being in reality in the nature of artifacts created by the suggestive influence of the physician and his own beliefs—a possibility that has been much stressed by critics. Unlike the discoveries made in the consulting-room, the data obtained from anthropological, literary and historical sources are fully available to all, so that the material on which the psycho-analyst bases his conclusions can be examined and assessed by others in a way that is not possible in the case of the material gained from the actual study of individuals by the method of free association, where much that is conclusive to the analyst actually present at the time is difficult to present in convenient and convincing form to others.

If the corroboration of psycho-analytic findings from these wider fields has done much to establish the scientific respectability of psycho-analysis, the wide vistas that have been opened up have shown in clearest fashion the immense importance of the psycho-analytic view-point for an understanding of the whole structure and function of human culture. The psychological mechanisms originally discovered by Freud in his consulting-room seem to have so wide an applicability that there is scarcely anywhere a religious belief, a ceremonial observance, a social institution or a conventional practice that does not bear their imprint. In theory it was clear from the beginning that the social sciences, such as anthropology, sociology, politics and economics, should be based upon psychology (much as engineering is based on physics, and medicine is, or should be, based on physiology). But, in practice, psychology had shown itself very slow in providing the foundation on which the social sciences could build. Both academic psychology of the more philosophical sort and the more recently developed experimental psychology were

[1] The more convenient word "parapraxia" has recently been introduced as a general term applicable to this field.

largely concerned with problems so abstract, or else so specific, that they had little relation to the affairs of everyday life. Psycho-analysis however was, from the first, concerned with the more concrete thoughts and emotions of individuals actually struggling with life's difficulties—difficulties moreover with which, in one form or another, all humanity has had to contend. Freud tells us that he ultimately came to realise that he had the whole of mankind for his patient. It would seem indeed that there can be no field of human endeavour, however great or small, concerning which we cannot receive profitable enlightenment from psycho-analytic concepts. Hence the great importance of a general understanding of these concepts, in the interest of human welfare and progress.

We will accordingly pass now to an examination of certain of the main theoretical conceptions of the Freudian psychology, to which the next section of this Article will be devoted. The third section will deal with the general process of mental development seen in the light of those conceptions and of the present state of our empirical knowledge, while in a few final words we will return to deal briefly with the general significance of psycho-analysis for modern culture.

One further word, however, is necessary before we embark on this programme. It is a word of caution which the title of this Article makes especially imperative. Psycho-analysis is not, and never has been, a theoretically perfect structure. Contrary to what has often been supposed, Freud and his fellow-workers started with no fixed conceptions of the nature and function of the human mind or of its disorders. Their theories have rather been in the nature of working hypotheses erected as scaffolding, indispensable for the further work of building. They have added to and modified these theories as this work has proceeded, but no attempt has ever been made to give them the dignified structure of a completed edifice. On the contrary they show, ever and again, evidences of a makeshift and temporary character. Psycho-analytical theory as a whole is today a rapidly growing body of doctrine. Its more recent development has, however, shown that the foundations of some thirty or more years ago were well and truly laid, and indeed we have good ground for supposing that the theory, as it exists at present, does not contain much that will later be regarded as definitely erroneous, though it will undoubtedly come to be looked upon as seriously incomplete. This, however, is the utmost that we can demand of any extensive theoretical structure in the realm of science.

II

THE NATURE OF MIND

Repression and the Unconscious

In the forefront of psycho-analytic doctrine stands a certain general assumption as regards outlook and method—the assumption of what has been called *psychic determinism*. By this is meant the belief that the law of cause and effect is as operative in the sphere of mind as in that of matter. Where introspection fails to reveal an adequate *conscious* cause of a mental content, it is assumed that unconscious mental factors are operative. It is

this assumption that theoretically justifies, and is in turn empirically corroborated by, the method of free association. The method is in fact based on the belief that, when conscious control of the sequence of thought is abandoned, unconscious factors take over the control, and express themselves as best they can in the ensuing conscious ideas and emotions.

This brings us to the most general and fundamental of all the concepts of psycho-analysis concerning the nature of the mind—that of the *Unconscious*. It is of course a concept which existed before the advent of psycho-analysis, and has indeed long been familiar both to philosophers and psychologists. Freud's use of the concept is, however, somewhat different from that of the great majority of his predecessors, and in its detailed application he has gone far beyond them all. Most of the earlier writers arrived at the concept of the unconscious through a study of knowledge; to these writers the unconscious seemed necessary to account for the phenomena of thought and perception, and, above all, of memory. This apparent necessity, which was felt by so many students of the mind, became much clearer and more urgent as a result of the work on hypnotism and psycho-therapy in the second half of the nineteenth century. This work had demonstrated the frequent occurrence in pathological cases of mental dissociation, a splitting up of the mind into two or more mutually inaccessible parts; parts which, in some instances, might even develop into "dissociated personalities," though in other cases the dissociated elements might be confined to a few isolated sensations or memories. Such cases of dissociation were accounted for by Janet (in whom this work may be said to culminate, and who is by almost universal admission the greatest living figure in psycho-pathology after Freud) on the hypothesis of a lack of "tension" or cohesive force, as though a reduction of the available energy made it impossible to hold all the varied portions of the mind together. Freud conceives of these dissociations, not in terms of lack of some general energy, but rather on the ground of some specific antagonism or opposition between the dissociated parts. His conception of the mind is essentially dynamic. He regards striving or conation (to use the generally accepted psychological term) as the real function of mind, and the opposition between different parts of the mind can, he thinks, best be expressed as a conflict between inconsistent and opposing mental tendencies or "wishes." Thus the primarily intellectualistic concept of the unconscious, that was prevalent before psycho-analysis, gave place to a primarily dynamic concept. In this point, as in many others, Freud has revealed himself as the scientific successor of the great pessimistic philosophers, Schopenhauer and Hartmann, rather than of his immediate psychological predecessors; we say "scientific" successor to emphasise that in his outlook he has (at any rate throughout his earlier years) been consistently more empirical than they, though the philosophical affinity between the three great thinkers is unmistakable.

Conflict then, according to Freud and his followers, is the essential cause of functional nervous disorder and of the dissociations so frequently connected with it. But this view of dissociation soon led to a distinction between two apparently different ways in which a thought or memory might be unconscious. A fundamental feature of the human mind, on which many psychologists have commented in wonder, is the extreme

narrowness of consciousness at any given moment. Of all the possible things which we could think, remember or perceive, only a minute fraction can enter consciousness at one time. The rest must wait till some external fact, some chance association, or some consciously directed desire, enables them in turn to occupy the stage. When their turn comes, however, they are ready to appear. It is otherwise with those thoughts or memories which are dissociated, and which have been shown to be concerned in the production of neurosis. In their case no external stimulus, no voluntary effort, can avail to bring them into consciousness; this can only be done (if at all) by the help of some special procedure, such as hypnotism or free association. It is as though some barrier or obstacle made them inaccessible, in a way that ordinary memories are not. All the psychic material of the first class Freud designates the *Pre-Conscious*. The second class he calls the *Unconscious*, employing the word in a special "systematic" sense.

Although the unconscious in this special sense (a sense which will be adhered to throughout this Article) plays an important part in the production of mental disorder, its importance is by no means confined to pathological cases. It is rather an essential constituent of every human mind, and, as already implied, it seems intimately connected with the occurrence of mental conflict, another feature which is common both to the diseased and to the healthy. It would appear, in fact, that one of the results of mental conflict is that certain thoughts and tendencies may be forced, as it were, into the unconscious (or, in other words, that they may be prevented from reaching consciousness). This process of active exclusion from consciousness is called *repression*, a term which, therefore, designates a particular kind of that general controlling function which is known to psychologists and physiologists as "inhibition." It should be noted that repression itself is an unconscious process—it is not a deliberate and voluntary pushing out of the mind, though it is undoubtedly analogous to this process, with which we are all consciously familiar.

We may here, in passing, call the reader's attention to the fact that, in his later writings at any rate, Adler has discarded the notions both of the Unconscious and of Repression—notions which are fundamental to the whole of Freud's psychology. We mention this to show how confusing and illegitimate it would be to designate the two now so different schools by one and the same name.

But if repression is one important outcome of conflict, it is far from being the only way in which a conflict may be solved. Indeed complete repression, in the sense that a mental tendency disappears utterly and for ever, is a theoretically limiting case to which, in actual practice, only certain approximations can be observed. There is every reason to believe that a wish is never completely annihilated by repression, but that it continues to exist in such a form that it is ready to seize any opportunity for expression that may present itself; indeed it is only through the continued vigilance of the repressing forces that it is prevented from entering consciousness. These repressing forces (which in their totality were called by Freud the *Censor*; a term which—because of its anthropomorphic associations—has been much criticised by English writers) are

less active in sleep, and the repressed tendencies (many of them dating from the first years of life) are enabled to express themselves in dreams. It is this which makes the dream, as Freud has said, the *via regia* to the unconscious. But such manifestations of the repressed as we detect in dreams are in most cases not direct, but distorted, expressions of the original wish ; and it is in this point that dreams so much resemble neurotic symptoms. Whence comes the distortion ? From the action, it would seem, of the Censor, who—like his social prototype—will allow certain facts or views to be expressed, provided they are suitably veiled, so as not to be easily recognisable for what they truly are. The dream product (the manifest dream content, as Freud designates it, to distinguish it from the latent dream thoughts), like the neurotic symptom, reveals itself, then, as a compromise arrived at as the result of the interaction of conflicting forces —repressing and repressed.

It is one of the paradoxes of the development of psycho-analysis that, at the present moment, much more is known about the repressed tendencies than about those which are responsible for the repression. In the earlier statements of the psycho-analytic theory, the repressions were regarded as resulting from the fact that the repressed tendencies were not in harmony with the moral consciousness of the individual or with the personality as a whole. It was generally believed, moreover, that the attitude of the Censor was more in harmony with conscious standards of thought and conduct than was that of the repressed wishes. It should therefore, one would imagine, be more accessible to investigation than these latter. With increasing insight, however, it became apparent that this was only to a slight extent the case, and that the morality of the Censor is, in reality, itself largely unconscious, differing in important ways from that of the conscious ethical outlook. The element of paradox was thereby removed, though at the same time a complex and difficult series of fresh problems concerning the nature and origin of this unconscious morality was opened up. We can deal with these problems more conveniently at a later stage of our considerations. Meanwhile we need only, by way of anticipation, state—baldly and dogmatically—three results of recent investigations in this field. In the first place there has been evolved a new concept concerning the unconscious morality in question ; this morality is regarded as a definite entity within the mind and is called the *Super-Ego*. It is, as it were, at the behest of the Super-Ego that the Censor does its work. In the second and third place the morality of the Super-Ego differs from that of the conscious Ego in that it is (*a*) relatively archaic (depending, that is, upon impressions formed during the early life of the individual and persisting in a condition that is but little modified by later experiences), (*b*) more severe, inasmuch as things that seem right and permissible to consciousness may nevertheless be disallowed in the unconscious. It is for this latter reason that Freud has made the statement that " the normal man is not only far more immoral than he believes [referring to the repressed tendencies] but also far more moral than he has any idea of [referring to the Super-Ego]."

Aggression and Sexuality

It is natural to ask at this point what are the chief thoughts and tendencies that are repressed. It is possible to answer this question quite shortly, without any serious sacrifice of accuracy ; the repressed material is, in the great majority of cases, either hostile or sexual in nature, with the latter category (so far as our present knowledge goes) very considerably predominating. That this should be so need not astonish us. For, granted that the process of repression exists, we should surely anticipate that hostile and sexual impulses would more often succumb to the process, since the most superficial reflection on our present culture is sufficient to convince us that the conditions of this culture constantly demand the control and inhibition of such impulses. How many times, even in a single day, are we not compelled to curtail or dissimulate the natural expression of our irritation at life's petty frustrations, humiliations and annoyances ! But, over and above these trivial sources of bad temper, there are long-standing and quasi-permanent causes of hostility (such as those occasioned by the necessity for co-operation or cohabitation of persons between whom there exists rivalry, jealousy or incompatibility of views and temperament), for which no adequate outlet can be provided. It is these latter sources of hostility, especially those connected with early life, which psycho-analysis has shown to be especially important as regards repression. The frustration of the sexual impulses demanded by our present (and perhaps indeed by any) civilisation is even easier to realise, if we devote a little candid introspection and observation to the subject. Nevertheless the revelations of psycho-analysis concerning sexual repression and the nature of the impulses that are repressed have aroused more incredulity and opposition than any other of its discoveries.

The Freudian doctrine of the nature and development of the sexual instincts is so important for the whole theory of psycho-analysis that we shall reserve it for more detailed treatment in the next section. We may here note, however, that the widespread antagonism encountered by these results of psycho-analytic research are only such as are to be expected, if the psycho-analytic theories themselves are true. In individual patients the process of making conscious the repressed tendencies meets, as we have noted, with very great resistance. But individual patients are, as we have also noted, by no means the only persons to suffer from repression —a mechanism which appears indeed to be a universal characteristic of mankind. We have therefore every reason to anticipate that, to the human race as a whole, the showing up of the general nature of the repressed material in psycho-analytic literature will be no more welcome than is the uncovering of their buried thoughts and impulses in the case of those who actually submit to the process of analysis. The well-nigh universal tendency to oppose the conclusions of psycho-analysis, a tendency which has manifested itself throughout the history of the movement, so far from affording an argument for the unconditional rejection of these conclusions, actually affords some evidence in their support.

We have said that the impulses which meet with the most frequent checks are those concerned with hostility and sexuality. One of the important differences between the school of Freud and that of Adler may

perhaps be said to concern the relative importance attributed to the inhibition of these two impulses respectively. Quite early in his history as a psychologist, Adler began to attach a greater importance to the frustration of the tendencies of individual self-assertion than did Freud—a tendency that was not unconnected with his own rebelliousness in general and his attitude to the founder of psycho-analysis in particular; for concerning this attitude Freud has recorded the significant words of his one-time disciple : " Do you believe that it is such a great pleasure to me to stand in your shadow my whole life ? "[1] Some of Adler's first and most interesting observations concerned the " inferiority of organs " and the psychological reactions thereto by way of compensation : by which he meant the tendency to over-compensate for a natural defect by developing the corresponding faculty so that the individual concerned eventually becomes superior in just that respect in which he was originally inferior—a doctrine which is undoubtedly of great truth and value, and which is exemplified in the well-known story of Demosthenes, who, from being a stammerer, became one of the greatest of orators. From this beginning, Adler continued to develop the doctrine of self-assertion by way of the " masculine protest " (the aggressive assertion of virility), until it soon became the all-absorbing element in his whole system. Psycho-analysts have not denied the importance of the factors to which Adler drew attention ; and, indeed, they have themselves in recent years devoted an ever-increasing attention to the ego elements, but their generally critical attitude towards his doctrines has been based upon the contentions :—(*a*) that, by neglecting the unconscious, together with nearly all the complicated details of mental functioning which had been so laboriously discovered by psycho-analysis, he has given an inadequate account of that part of the mind which he has treated (thus he fails to make sufficiently clear the fact that many of the original inferiorities—stammering, for instance—were themselves the result of deep-lying inhibitions, and that their over-compensation is in the nature of a " return of the repressed " in a form that is ethically more permissible) : (*b*) that his psychology altogether overlooks the importance of the erotic aspect of life, and is thus essentially and inevitably one-sided. According to his system, the impulse of aggression is all-important, there is no room for love. As Freud has remarked, it is a cheerless aspect of life that is presented ; but, as the example of innumerable ascetics shows, almost anything is acceptable, so long as sexuality is kept at bay—a task in which Adler's psychology is almost as successful as was academic psychology before the advent of psycho-analysis. Our task here is not to criticise Adler's psychology or any other, but to expound psycho-analysis. Some brief indication of the distinctions between the two systems is however imperative, and this first approach to the subject of sex seemed the natural place to attempt such indication. Lest it be said that Freud's " pan-sexualism " (a term that has sometimes been used by his critics) is no less one-sided than Adler's insistence on the ego, it is only fair to remark here that Freud has, time and again, emphatically stated his belief that the sexual tendencies, though of immense importance, do not exhaust the instinctive equipment

[1] S. Freud: *History of the Psycho-Analytic Movement* (1916), p. 42.

of man, and that psycho-analysis has in the course of its development continually broadened the range of its observations and its theories, without thereby sacrificing the earlier acquisitions. Adler's Individual Psychology on the other hand has become more and more rigid in its accent on aggressiveness as an all-pervading and all-important factor, and has, with ever greater determination, set its face against the intrusion of sexual or other influences.

Symbolism

The view of psycho-analysts that repressed material is very largely of a sexual nature is rendered all the more unacceptable to the majority of people by a further aspect of their doctrine—the importance that they attach to sexual symbolism. As we have already noted, repressed impulses seldom exist without making themselves felt in consciousness in some way or other—though the way may be so indirect that the true underlying meaning is often not appreciated ; indeed this lack of appreciation is often an essential condition of their manifestation. Now one of the most important of these indirect ways of manifestation is that of symbolism. Not the least of the achievements of psycho-analysis is that it has led to a realisation of the widespread use of methods of expression, whereby sexual or other inhibited material is portrayed in such a way that it is not immediately or easily understood. We have said that psycho-analysis is responsible for the "realisation" rather than for the "discovery" of sexual symbolism, for the reason that the discovery of this symbolism had already been made by students of religions of the East and elsewhere : students who had—above all—endeavoured to make clear to an incredulous world the wide importance of the phallus in many aspects of religious ceremonial. Psycho-analysis has proved that symbolism of this kind is not confined to primitive peoples or to the civilisations of the East, but that it appears to be a general characteristic of the human mind. Indeed one of the most valuable contributions of psycho-analysis has been to show, here as elsewhere, that the same phenomena can be observed in many different aspects and products of the mind. Actually, it was in their study of dreams that psycho-analysts first encountered symbolism ; but, as the work proceeded, it soon became apparent that precisely the same symbols, with the same interpretation, could be discovered in religion, language, ceremonial, myth and fairy story. There still exist many fascinating but unsolved problems in connection with symbolism,[1] problems which we cannot deal with here. In particular, it is still uncertain how far symbolism results from repression, or how far repression merely leads to the employment of a mode of expression which has come into being for quite other reasons. There is considerable evidence to show that symbolism is a necessary and inevitable feature of the primitive mind (and therefore also of the primitive layers of the cultured mind). But that there is the closest connection between symbolism and repression, is indicated, not only by the study of

[1] The fullest treatment is that of Ernest Jones in *Papers on Psycho-Analysis*, 3rd edition (1923).

innumerable individual cases, but by the general fact that the field of interest that would seem to be most universally repressed—namely that of sex—is also the field with which the majority of symbols deal.

In symbols, as in every case of indirect expression, there exists a mental relation between the symbol and the thing symbolised. The ease with which this relation can be discovered varies greatly, however, from one case to another. As a case where the relation is fairly plain, though nevertheless of such a kind as to escape recognition by the vast majority of those to whom the symbol is familiar, let us take the wonderful lamp of Aladdin, which will afford the gratification of every wish. Here it should be plain enough, once it is pointed out, that the lamp itself is a symbol of the phallus, and the happiness to be derived from it (by the appropriate magical gestures) a scarcely veiled allusion to sexual gratification. But why a lamp ? The middle term is here supplied by the idea of warmth and fire, which seem always and everywhere to be associated with love, passion and sensuality, as is shown in such common expressions as " on heat," " a warm embrace," " an ardent affection," " hot stuff," " a burning desire " (with which compare " a frigid woman " and " a chilly reception ") and in the innumerable rituals in which fire plays a part, from the religious creation of fire (by friction) among primitive peoples to the lamp-lighting ceremonies of certain present-day societies.

As another transparent example let us take the well-known rhyme :—

I had a little husband no bigger than my thumb,
I put him in a pint pot and there I bade him drum.

Taken literally, this is almost complete nonsense ; interpreted symbolically as the act of coitus, the meaning is perfectly clear. This interpretation of the total idea is, moreover, borne out by the frequent occurrence of the individual symbolisms involved. The " little husband " is a case of the " little man," dwarf or gnome as a representation of the phallus, of which Rumpelstiltskin and Punch are among the best-known examples ; the process here being a substitution of *totum pro parte* instead of the still more usual one of *pars pro toto.* The thumb as phallic symbol is an example of the general tendency to substitute a more harmless portion from the upper part of the body for the more emotionally significant but relatively unmentionable parts of the lower trunk—a tendency that is perhaps especially manifested in dreams. The pint pot is an example of the very numerous cases where a vessel, receptacle or enclosed space serves as a feminine symbol, as contrasted with the complementary class of phallic symbols.

Let us now take two more difficult cases to contrast with these. There is a considerable amount of evidence to show that a cloak or mantle may often serve as a phallic symbol. Here there is no similarity of outward form between the symbol and the thing symbolised. So different do the two things seem that it is almost unimaginable that such a symbol could have been consciously elaborated in accordance with a pre-conceived theory (thus affording additional evidence for the truly empirical basis of the psycho-analytic views on symbolism). As far as the evidence at present available goes, it would seem that the missing link is here to be

found, once again, in the notion of warming, which is of course the function of a cloak.

Scarcely less obscure at first sight is the symbolisation of coitus by means of climbing or walking upstairs. Here the essential common thoughts are those of rhythmic movement and the actual position adopted in the reproductive act; while linguistic usage helps us again by the corroborative evidence afforded by such phrases as " *un vieux marcheur* " (an elderly *roué*).

Symbols are, as will perhaps have been gathered by this time, extremely numerous and varied. Nevertheless the number of things symbolised is relatively small. They are, without exception, things of high emotional significance, and include (1) the human body or certain portions of the body, especially the genital regions ; (2) certain bodily excretions, such as semen, fæces and urine ; (3) certain persons, especially the father and mother ; (4) certain biological events or processes, especially birth and death. Among the more important symbols falling into the first class are long, pointed objects, weapons, knives and other instruments, serpents, fish, Zeppelins, all these being male symbols. The corresponding female symbols are hollow and round objects, jewels, gardens and flowers. The process of tumescence is often symbolised by flying, while the human body as a whole is most often represented by buildings (with doors and windows corresponding to the bodily orifices), and by landscapes (with hills and valleys corresponding to the protuberances and depressions of the body—*cp.* the anatomical term "Mons Veneris"—and woods corresponding to the hairs). Dancing, climbing and other rhythmic movements represent coitus, while sliding, and extraction or losing of teeth, correspond to auto-erotic activities. In the second category we find, for instance, that salt stands for seed, money and papers for fæces, water and fire for urine. In the third category there exists a general tendency to portray the father and mother by more exalted personages, especially a king or queen, though the parents, and especially the father, may also be represented by certain animals (this latter symbolism linking up such apparently unrelated phenomena as the totemism of primitive peoples and the animal fears of present day neurotic children). In the fourth class, birth is most often represented by going into, or coming out of, water, a hole, a tunnel or a house, while death appears as going on a journey (*cp.* use of the term " the departed," the constantly recurring notion of the soul's journey after death and Hamlet's well-known reference to " the undiscovered country from whose bourne no traveller returns ").

It is clear that symbols of the kind we have been discussing are, in certain respects, different from such other forms of indirect representation as that in virtue of which a wedding ring stands for marriage, or certain conventional female figures stand for such abstract virtues as liberty or justice. In these latter cases the things symbolised are in the preconscious rather than in the unconscious ; in other words, there is no special difficulty about bringing these things to consciousness. The emotional elements of the relationship are also strikingly different in the two cases, for, whereas in the first kind, where the thing symbolised is unconscious, its emotional value is greater than that of the symbol, in the

second kind just the opposite holds good. This can be seen clearly in those cases where the same object serves as a symbol of both kinds. Thus a serpent may stand both for the phallus and for wisdom, but whereas the emotion accompanying the idea of the phallus is greater than that aroused by the idea of a serpent, the serpent is itself of greater emotional significance than is the abstract idea of wisdom. Indeed a consideration of the two kinds of symbolism gives us very strongly the impression that the symbolic process is used by the mind for different ends in the two cases—that in the first case the aim is to reduce the total emotion by substituting a relatively harmless and uncensored object for one that appeals more strongly to our primitive desires (though at the same time permitting some discharge of our feelings through this indirect channel) ; and that in the second case the purpose is rather to endow with the additional instinctive energy attaching to some emotionally toned concrete object an idea that in itself appeals rather to the intellect than to the passions. The writer who has devoted most attention to this subject,[1] has proposed that different terms shall be employed in the two cases, that the word " symbol " should be confined to instances of the first kind, and that some such term as " metaphor " or " emblem " should be used when referring to the second. It seems doubtful whether it will be possible, or even desirable, thus to narrow the meaning of " symbol," and the present writer has tentatively proposed the term " cryptophor " as a suitable designation for those cases that contain " hidden " meanings not ordinarily or easily accessible to consciousness. But whatever term be adopted, there can be little doubt of the psychological value of the distinction.

It would seem, however, that we may be compelled to recognise more than one kind of cryptophor or true " symbol," to use Ernest Jones' term. In particular it would seem necessary to distinguish between " material " and " functional " symbols. Whereas " material " symbols deal with corporal or external objects and events (all the cryptophors that we have so far mentioned are of this class), " functional " symbols express states and tendencies of the mind. These states and tendencies may be of a temporary or, in extreme cases, almost momentary character (such as the attempt to solve a given problem, or the process of transition from a sleeping to a more wakeful state), or may be of a more stable nature, in which case the symbols appear to denote permanent and abstract features of the mind, such as the instincts, the power of moral control, the tendency to return to infantile ways of thought, etc.

It is generally agreed that such " functional " symbols occur, but there is a great difference of opinion between psycho-analysts proper and certain other psychologists as to their importance as compared with that of the " material " symbols. This divergence is particularly acute as between the school of Freud and that of his erstwhile follower Jung. Discovered in the first place by a special technique devised by Herbert Silberer, functional symbols were seized upon by Jung as a means of escape from what seemed to him the monstrous, repellent sensuality and infantilism of the unconscious as revealed by Freud. They soon became the real centre of interest in his researches, and it is in connection with them that most of the distinguishing features of his system had

[1] Ernest Jones: *op. cit.*

their origin. Instead of studying the individual concrete wishes of the patient, wishes towards particular persons or objects, Jung began to look everywhere for symbolic representations of general mental tendencies, and above all for symbols of the libido. The term " libido " had been used throughout by Freud to designate the sexual impulse in all its various manifestations (a conception with which we will deal later). By Jung it was widened so as to designate the sum total of the creative forces of the mind, becoming thus more or less synonymous with the Bergsonian term *élan vital*. In practice this amounted to a very much smaller emphasis upon the concrete sexual motives and to a development in the direction of very wide and somewhat mystical generalisations—a development which has seemed to psycho-analysts to involve the abandoning of nearly all the hard-won insight into the nature and importance of the sexual elements of the human mind.

To take a concrete and frequently recurring instance. There are innumerable myths and dreams which portray in somewhat disguised form the slaying of a father by a son and the love of the son for his mother—a theme which occasionally finds a relatively open expression, as in the well-known myth of Œdipus. To many followers of the Jungian tradition the principal significance of such a theme is to be found in a symbolical portrayal of the struggle to overcome primitive, unadapted and immoral tendencies (*e.g.* " the old Adam ") and a necessity for a return to the depths of the unconscious in order to gather strength for a new effort—a sort of *reculer pour mieux sauter*. To the psycho-analyst these meanings might be regarded as quite possible in certain cases, but as secondary and relatively superficial constructions, which we must not allow to distract us from the underlying " material " symbolism, which portrays the literal hatred of the son for the father, and the literal incest wish towards the mother. To him the functional interpretations of the analytical psychologists seem to have much the same significance as the interpretations of certain schools of mythologists of an earlier generation—mythologists who, in accordance with the then popular " astral " modes of thought, would interpret the murder of Laius by Œdipus as the triumph of the rising sun over the darkness, and the incestuous marriage with Jocasta as the apparent sinking of the sun into the sea or earth at sunset. Both tendencies they would regard as motivated principally by the desire to escape the unpleasant implications of the more significant, simpler and more literal meaning. It is for this reason that psycho-analysts have looked upon much of the later work of Jung with very grave suspicion, though they universally agree that in his earlier years he contributed much of value to psycho-analysis itself, particularly by his insight into the possibilities of the word-association experiment and by his pioneering application of psycho-analysis to certain cases of dementia præcox. The difference in method and outlook between the two schools has only widened with the lapse of time, and in their later developments psycho-analysis and analytical psychology have proceeded in almost complete independence of each other. We shall therefore not be called upon to investigate the more recent features of Jung's psychology, such as his elaborate doctrine of types, which, however important it may ultimately prove to be, cannot be regarded as in any sense a product of

psycho-analysis or a feature of psycho-analytic theory. There is, however, one further point in Jung's psychology which deserves mention before we leave the subject. Jung, unlike Adler, continues to make use of the concept of the Unconscious. He considers, however, that the unconscious is not entirely a personal and individual affair ; over and above the " personal unconscious," each individual, according to him, shares in the " collective unconscious," in which not merely the form but also the content is determined by heredity. This view implies the old and widely-abandoned doctrine of " innate " ideas ; it means that our hereditary equipment is not confined to general tendencies, predispositions and capacities, but that ideas themselves are to some extent transmitted. If we could accept this doctrine, it would of course clear up the otherwise difficult problem as to why certain notions so constantly figure in the unconscious and why symbols nearly always bear the same meaning. Freud himself has been so struck with the frequency and similarity of certain " primal phantasies " (such phantasies for instance as castration or the overhearing of sexual intercourse between the parents) that he too is inclined to consider that they cannot be entirely accounted for in terms of the individual's own experience. Many other psycho-analysts however still hope to explain the uniformities in question on the ground that, owing to the similar conditions of life and the similar operation of the fundamental instincts, all human beings have necessarily many of their deeper interests, hopes and fears in common.

Condensation and Displacement

We said just now that it is generally agreed that functional symbols actually occur. We might have gone further and asserted that the same symbolic material may serve at one and the same time in a functional and in a material sense. That such a double significance of a single conscious item is possible, is due to an interesting tendency of the mind, the far-reaching importance of which Freud was the first to realise. Given, as so often happens, the simultaneous arousal of two desires or intentions, seeking different expressions, the mind most easily deals with the situation by way of a compromise, in which both elements are to some extent represented. Examples of this from everyday life are to be found in the " portmanteau-word," the pun and the *double entendre*. This last shows indeed some superficial resemblance to (cryptophoric) symbolism, inasmuch as one meaning is, as it were, paraded for the sake of respectability, while the emotion is derived from a partly hidden significance of a less presentable kind. Many symbols, however, together with many neurotic symptoms, may have two (or more) meanings, which are both (or all) unconscious. Indeed, resort to compromise of this kind appears to be one of the striking characteristics of the Unconscious. The process of compromise is called in the technical literature *Condensation*, when the fusion is primarily one of ideas ; *Over-determination*, when it is a question rather of simultaneous " drives " or wishes.

The ideas or wishes in question may, it appears, have almost any relation to one another. They may be quite independent and unconnected except for chance coincidence, or else (and perhaps most usually and

significantly) there may be a certain relation of oppositeness or incompatibility between them. Indeed one of the most remarkable revelations of psycho-analysis concerns the frequency with which people harbour simultaneous but irreconcilable wishes, wishes which are in many cases in the nature, not only of logical contradictories, but of contraries, as when a person wishes to do and not to do a thing, or wishes to do a thing and at the same time to do its opposite. When two wishes of a directly contrary kind are simultaneously operative, the attitude of the person concerned is said to be *ambivalent*. The most important kind of ambivalence is that which occurs when a person at the same time both loves and hates another person—an attitude which is surprisingly frequent as between near relatives, and indeed between all people whom the circumstances of life bring into intimate and influential relationship with one another.

The scope of this Article does not admit of extensive illustrative amterial, which—in psycho-analysis even more perhaps than elsewhere—necessarily demands much space. For such material the reader must be referred to the text-books, special treatises and journals devoted to the subject. Nevertheless, since the full significance of over-determination and ambivalence are particularly difficult to realise without some illustration, and since such realisation is essential to a proper understanding of many of the most essential features of psycho-analytic theory, we may pause here to consider two brief examples—one from the domain of wit, the other from that of dream life.

First the case of wit. Let us take the story of the Englishman who offended against the law of *lèse majesté* in Berlin in the days before the Great War. This Englishman held strong and unfavourable views about the Kaiser, and did not fear to express them to a companion even in the street. One day he was overheard by a policeman to make an emphatic statement beginning with the words "This damned fool of an emperor . . ." The policeman quickly arrested him, and informed him of the nature of his crime. But the Englishman, with remarkable presence of mind, attempted a bold method of escape. " My dear man," he said, " surely you don't suppose I was talking of the German emperor. I wouldn't dream of talking like that about the German emperor. I have the greatest admiration . . ." But the policeman was not to be so easily put off. " Come, come," he said, " that's no use at all. I know very well whom you meant. There's only one damned fool of an emperor and that's ours ! " Here the policeman manifests an ambivalent attitude, both towards the emperor and the foreigner. He admits with the Englishman that the Kaiser is indeed a fool ; but at the same time he protects the latter from the disrespect of an outsider (in much the same way as a man will defend his family honour before a stranger, though he may live in private enmity with all members of this family). Contempt and respect are, therefore, both neatly gratified by means of the same formula. He has the satisfaction of doing his duty by arresting an impertinent foreigner ; but, by identifying himself with the latter's point of view (and thus to some extent sympathising with him), he makes a sly dig at his own imperial master (doubtless glad enough of an opportunity of expressing at last an opinion which he himself had long held, but never dared to utter

—at any rate in the course of his official duties). The over-determination in this case is the essential element of the wit. Similar over-determinations, but more complex in structure, at a deeper level, and with direr consequences, would seem to be at work in all cases of neurotic illness. Essentially the same, but on a still grander and more tragic scale (though again not without an element of the ridiculous), are the psychological mechanisms that underlie many of the cherished religious, political and social beliefs and institutions of the human race.

To turn now to the dream example. To analyse a dream of any length or complexity would require many pages. Here we will take therefore a very short and simple dream, but one which is well suited to our present purpose, inasmuch as it reveals itself as highly over-determined. A female patient undergoing psycho-analytic treatment dreamt that: " The tuner had come to tune the piano. He was engaged in taking out a number of seeds from the inside of the piano." Short as it was, the analysis of this dream occupied a whole hour's session, and revealed very clearly the following symbolisations and over-determinations. The dreamer herself is represented by the piano, a choice of symbol that is partly determined by the circumstance that she was a proficient amateur musician (though her own instrument was the violin) and partly by the fact that she was suffering from serious worry and overwork at the time of the dream, and that she had herself, the day before, expressed her longing " to go *piano* for a bit," *i.e.* to take life more easily. This desire " to go *piano* " (represented symbolically by actually being a piano) is the first and most superficial wish-fulfilment of the dream. The tuner is a symbol of the analyst —one indeed that is apt enough, for there is an obvious analogy between the relation of a tuner to a piano and that of an analyst to his patient. The dream therefore contains a reference (as so many dreams do) to the analytic situation itself. But why is the tuner (analyst) removing seeds from the piano (patient)? With this question we come to the sexual elements which are so seldom lacking in dreams, for seed, here as elsewhere, refers to the biological processes of reproduction. But the associations made it evident that there were three distinct meanings within this general sphere. In the first place seeds refer to certain sexual desires, which, as the analysis was making her realise, she had all-unknowingly harboured in her mind. The analysis, she hoped, would rid her of these, as it seemed to her, evil and unseemly desires. Hence the analyst was symbolically removing them. This is the second wish-fulfilment. It will be observed that it is one that fits in pretty well with the interpretations that have been stressed by Jung and his school, for the " seeds " may with some justice be regarded as a symbol of the libido itself (though, it is true, in a narrower and more definitely erotic sense). But there are two further wish-fulfilments of a cruder and more instinctive kind. The word " seed " can be metaphorically used for " offspring," and the third meaning of the dream is that the analyst is acting as the patient's accoucheur at the birth of a child. Lest the reader be astonished and disgusted, let him remember that Socrates, who with his motto " Know thyself " appears to have been in some ways very definitely a forerunner of Freud, likened his own spiritual labours to those of a midwife, who helped women to the birth of children in much the same way as he himself helped men

to the birth of self-understanding. Fourthly, and finally, the dream represents the opposite of taking out, *i.e.* putting in; in other words, the analyst is thought of as putting his seed into the patient. Here the reader who is untrained in psycho-analysis is likely to remain incredulous. But before he definitely rejects this interpretation as both unpleasant and absurd, we would mention three sources from which evidence from analogy is forthcoming to support it. In the first place the condensation of the ideas of coitus and birth is one that is found to be of very frequent occurrence in psycho-analysis. It is as if the unconscious tended to identify the two processes as marking the two most interesting points, the beginning and the end, of the cycle of gestation, bridging over, as it were, the nine months that intervene. Secondly, as regards representation by opposites (in this case the symbolisation of "putting in" by "taking out"), we must remember that this process is by no means confined to dreams (where it is frequently found), but is familiar to us through that conscious expression of humour and hostility that we term irony. Thirdly, as regards the rôle of the tuner (analyst), this is the place for referring to what is found to be a constant feature in psycho-analysis, namely that the person of the analyst becomes invested with a very high degree of feeling, both of love and of hate—emotions that are derived from the psychological relationships in which the patient has stood to persons of importance in his earlier environment (parents, nurses, teachers, etc., but especially the first named), and which in the course of the analysis are temporarily transferred to the analyst himself; whence the technical name for this process, which is called Transference.

To sum up the features of this dream which here especially concern us.—The dream reveals itself as highly over-determined, inasmuch as it gives expression to four distinguishable wishes: (1) to get rid of worry and overwork ("go *piano*"), (2) to get rid of disturbing sexual desires, (3) to give birth to a child with the help of the analyst, (4) to have sexual intercourse with the analyst (*i.e.* to receive a child from him). It may be noted that the second wish is incompatible with, and may even be regarded as the opposite of, the third and fourth.

With these examples in mind, let us return now to our general consideration of the principal concepts of psycho-analysis. The phenomenon of *Transference*, to which we referred just now as a factor entering into the interpretation of our dream example, is by general consent a matter of the greatest importance in the therapeutic aspects of analysis. It occurs without exception in every case where the analytical process succeeds in getting far enough to overcome the resistances in the initial stages; and it is essential to ultimate therapeutic success. It is as though, in the course of the analysis, there took place a living over again of emotional attitudes towards the most significant persons in the patient's past life—though this reliving is now done in relation to the analyst himself, who appears to take on the characteristics of these earlier persons. The emotions concerned are those of fear and hate, as well as of respect and love—hence the attitude of the patient towards the analyst is apt to be highly ambivalent. The reliving of these emotional attitudes is however itself, for the most part, an unconscious process—and one of the most difficult tasks of the analysis is the conversion of this tendency to repetition into an

insightful remembering, so that the origins of the attitude of the patient to his analyst are recognised for what they are. In fact the transference can to some extent be regarded as a new and artificial neurosis, which, in its turn, is analysed; and with the successful completion of this part of the work, the analysis itself draws to an end. It is the difficulty of inducing transference in patients suffering from genuine insanity that appears to be the chief obstacle to the therapeutic application of psycho-analysis to such cases.

Transference, which thus plays such an important part in the practice of psycho-analysis, can in theory be regarded as only a particular example of a wider process—that of *Displacement*, which can be defined as the (quite general) transference of an emotional attitude from one idea to another. The occurrence of some such process has long been acknowledged by psychology, and indeed the process is an easy one to recognise without any special training (as when we are put into a bad temper by someone who has not acted according to our wishes, and thereafter for a time tend to behave in a curt or irritable way to all who approach us, however innocent and inoffensive in themselves). Fundamentally it would seem to be the emotional equivalent to the law of association in the sphere of cognition, and indeed it is, to some extent, in its actual working, dependent on this law; for displacement takes place, not in haphazard fashion (though in certain cases, as in the simple instance just noted, it may be very diffused) but, like symbol-formation, according to certain definite relations, which can usually—though not always quite easily—be detected. According to psycho-analytic theory, displacement is a mechanism of enormous importance for the development of mind; and indeed many of the most valuable contributions of psycho-analysis to the study of mental growth consist in the discovery of the precise nature of the individual displacements that most frequently occur. It would seem that man is born with a limited number of hereditarily determined reaction patterns (themselves of varying degrees of complexity and determinateness) and that, thereafter, as he develops, these reaction patterns become complicated by the facts: (*a*) that any given reaction can be evoked by an ever-increasing variety of stimuli, and (*b*) that it can itself (together with its emotional accompaniment) undergo important modifications, so that at first sight the whole reactive process may eventually appear to have little in common with its original and primitive form. This general view is held by the great majority of present-day psychologists, including even the school which represents the opposite extreme to that of psycho-analysis. Behaviourism (which may be said to occupy that position because it endeavours to ignore consciousness altogether), in its studies of the "conditioned reflex," is concerned with the change in the nature of the stimulus. Psycho-analysis (which extends the sphere of the conscious, by analogy, into that of the unconscious) is concerned with the wider aspects of the developmental changes, not only those of stimulus, but those of emotion and response. It is not therefore in the general doctrine of displacement, but rather in its particular contributions to the doctrine, that psycho-analysis is distinguished from other schools of psychology (though the term itself is still peculiar to psycho-analysis).

In the course of development there are formed certain displacements of especial social and cultural value. Indeed, if psycho-analytic theory be right, civilisation is possible only through displacements of this sort, as a result of which the myriad activities of civilised societies gradually evolve out of the relatively simple and primitive innate tendencies of man. Such displacements have received the special name of *Sublimation*, a technical term that, unlike " displacement," has found its way into general psychological literature, and indeed to some extent into common speech. A considerable portion of our third section will be devoted to indicating the chief forms of sublimation, as at present discovered by psycho-analysis, since this constitutes one of the most assured and at the same time one of the most interesting parts of psycho-analytic theory.

Other displacements however seem to be pathological in nature, and it is these that find expression in the various *symptoms* that are characteristic of nervous disease. Psychologically a neurotic symptom and a sublimation have much in common, since both represent a deflection of energy; the most obvious difference being that of the relative value for cultural achievement and individual happiness—a difference that is social or ethical rather than psychological. But closer inspection reveals a psychological difference also. The neurotic symptom appears always to be the outcome of mental conflict, and itself is in the nature of a compromise between the opposing forces engaged in the conflict; like most compromises, moreover, it gives lasting satisfaction to neither party concerned. It seems to result from an attempt at repression, but an attempt that is only very partially successful (the repressed tendencies having found a circuitous channel of escape; a channel that often stands in some symbolic relation to the one that was originally sought). The relative influence of the repressing and the repressed forces varies from one kind of symptom to another, and this variation is to some extent a characteristic of the various forms of nervous disease that are clinically distinguished. Thus in hysteria (whether the symptoms are chiefly mental, as in so-called "anxiety hysteria," or chiefly physical or sensory, as in " conversion hysteria "), analysis of the symptoms reveals for the most part a distorted expression of a repressed wish; while in " obsessional neurosis " (in which the patient is plagued by compulsive thoughts or actions) the symptom seems rather to be in the nature of an over-compensation against the inhibited desire, and thus chiefly gives expression to the repressing forces of the mind. Symptoms of this latter kind belong to the class of so-called *Reaction-formations*. The existence of such reaction-formations—often, but not always, of an obviously neurotic kind—can frequently be recognised in ordinary life. One thinks naturally of two very common types: the shy young person who, in order to overcome his timidity and sense of inferiority, becomes somewhat curt, loud, rude or blustering in his behaviour; and the prudish " old maid " who is so constantly on the defensive against her own repressed sexuality, that she scents sex everywhere, and consequently reacts with shame, disgust or disapproval, when confronted with words or acts that seem to others perfectly innocent and harmless.

The element of conflict and repression is much less in evidence in the case of sublimations. It would seem here as though the viability of the

channel depended on conditions that are much more stable than those in neurosis. There is an appearance of smoothness, relative effortlessness and lack of friction, that contrasts strikingly with the impression of struggle and waste of energy that one receives from the study of neurotic symptoms. It is as though the sublimated channel were a really adequate substitute for the original and cruder one, and were capable of providing a gratification which, though different in quality (and often less in intensity) than that of the corresponding primitive impulse, is no less satisfactory ; the ardour with which people give themselves over to the pursuit of true sublimations being often but little inferior to that which accompanies pleasure of a more sensual kind. Psycho-analytic theory has not as yet definitely committed itself as to how far repressions are necessary for the production of sublimation. On the whole the evidence points pretty strongly towards the necessity of some kind of inhibition of a more primitive satisfaction as a condition of sublimation. But the inhibitions themselves are relatively deep-seated and efficient, and (since they do not interfere greatly with the quantity, and impose restrictions only on the forms of satisfaction), they seem to meet with comparatively little opposition, the instinctive energies flowing easily and naturally into the new substitutive channels.

From what has been said, it will be clear that the goal of development to which psycho-analytic theory points is that of sublimation—a goal which signifies at once mental health for the individual and cultural progress for society. Psycho-analysis has made us realise, however, that the achievement of sublimation is not an easy task, but is on the contrary an end which can only be attained by slow and gradual steps. Neurosis comes about largely through a sort of moral impatience on the part of the individual and society. To achieve the maximum of sublimation we shall find it necessary to be more tolerant to the demands of instinct than has hitherto been the case. Sublimation itself is an unconscious process which is outside the sphere of voluntary control. All we can do is to provide the means for its occurrence, remembering meanwhile the inevitable gradualness of the whole process. This is one of the great lessons of psycho-analysis, both to the educator and to the social reformer. It is a theme to which we shall return in our concluding section.

III

THE DEVELOPMENT OF MIND

General Theory of Development

The psycho-analytic theories of mental development are inextricably bound up with the psycho-analytic theory of sex ; it is therefore necessary for us to consider together these two aspects of our subject. The psycho-analytic conception of sex is a somewhat unusually wide one, and includes a good many processes that are at best only indirectly connected with the process of reproduction. The terms " Libido " and " Sex," as used by Freud, are in fact used somewhat similarly to the " Love " of Christian

tradition or the Platonic " Eros," though the psycho-analytic views as to the nature and development of " Sex," are far more detailed and precise. According to these views, normal adult sexuality results from an integration of a number of what were originally more or less independent impulses—technically termed *Component Instincts*. Perhaps there was originally a vague erotic quality—the earliest precursor of the sexual instinct—attaching to all sensations coming from the surface and from the interior of the body, but from birth onwards there are certain special zones, regions or organs which are specially endowed with this quality, and to each of which there may be said to correspond a particular component instinct—an instinct, that is, which urges the individual to seek the gratification obtainable by appropriate stimulation of that zone or organ. Other component instincts are more loosely connected with anatomical regions and are classifiable only on the basis of the peculiar activities or feelings connected with them. No psycho-analyst has as yet attempted a complete enumeration or classification of the component instincts.[1] Among the most important are the following :—(1) those connected with the mouth (the so-called "oral" component instincts). As observation of any very young baby will show, these are of especial importance in the first few months of post-natal existence ; a period which, for this reason, is often called the oral stage ; (2) those connected with the opposite end of the alimentary canal, *i.e.* anus and rectum (the " anal " component instincts) ; these are particularly important in the next stage of development, and it is in regard to them that some of the most sensational psycho-analytic discoveries have been made ; (3) those connected with the organs and processes of micturition (the "urethral" components); (4) those connected with the genital organs proper ; (5) those connected with the activities of vision, which are divided into two main groups—the active or " scoptophilic," and the passive or " exhibitionistic " ; (6) those connected with the infliction or endurance of pain—again divided into an active or " sadistic " group, and a passive or " masochistic " group.[2] In addition to these, there are certain other components, such as those connected with the muscles and the skin, the sense of smell, the auditory sense, which have as yet been insufficiently studied by psycho-analysts and about which in all probability a good deal still remains to be learnt.

In the course of normal development, these various component instincts become co-ordinated and organised under the leadership of the genital components, so that they ultimately come to serve, at least indirectly, the purposes of reproduction. Analysis of normal sexual behaviour can indeed easily reveal the presence of some at least of these components. Thus the erotic excitations connected with seeing and being seen are among the most familiar of the initial stages of the whole sexual cycle. They play a prominent and essential part in courtship in man as

[1] Freud's *Three Contributions to the Theory of Sex* (1916) is, in its later editions, still the most complete and systematic account.

[2] So named after the Marquis de Sade (1740–1814) and Sacher Masoch (1836–1895), well-known individuals whose sexual life was strongly influenced by the component instincts in question.

well as in many other of the higher animals, for, wherever vision is the most important distance receptor, the first intimation of the presence of a possible mate must be conveyed through the eye. Reference to the kiss is sufficient to recall the general importance which the oral components retain in ordinary sexual life. A certain amount of aggressiveness in the normal male attitude gives evidence of the rôle of sadism, while female passivity entails a certain element of masochism. Skin and muscle erotism are likewise normally involved to some extent. Perhaps the anal and urethral elements are the only ones to play no obvious part in normal sexual life ; and this fact is bound up with two important further aspects of psycho-analytic theory, to which we now pass.

In the first place the process of organisation of the component instincts, to which we have just been referring, goes on simultaneously with the process of displacement and sublimation with which we dealt in the last section. In virtue of sublimation, each component instinct, in the course of its development, transfers a certain amount of its energy to non-sexual goals, and upon this process of displacement a good deal both of social culture and of individual character depends. It seems probable that, on the whole, the component instincts which can least easily find an adequate place in adult sexuality undergo the most extensive and varied forms of sublimation and displacement ; this is strongly suggested, at any rate, in the case of the anal components, which—as we shall see—while contributing little to normal adult sexuality itself, exercise a most wide-spread and ramifying influence elsewhere.

In the second place, coincident with the development of the component instincts with regard to integration, there is development with regard to object. It has become customary to distinguish three main stages of this latter aspect of development. In the first or *auto-erotic* stage, each instinct seeks its own satisfaction, more or less as an end in itself. The erotism of the very young child must be conceived as being exclusively of this type, but some degree of auto-erotic activity remains throughout life. Eating sweets, smoking, onanism and scratching of the skin are adolescent or adult forms of auto-erotism which will naturally occur to the reader. Other activities, such as dancing or gymnastics, which are to some extent upon another plane, contain important auto-erotic elements (in this case chiefly of the muscular components), while the anal components, in so far as they are not displaced, tend to remain permanently auto-erotic in character.

The second stage is that of *narcissism*. Here there is organisation and direction of love towards a definite object. This object, however, is the self (hence the name, which is of course taken from the mythical figure of Narcissus). The doctrine of narcissism has considerably complicated psycho-analytic theory, inasmuch as it has destroyed the simple outlines of the dualistic division of human tendencies into those of self and sex (since much that a facile *a priori* explanation would ascribe to the ego is now seen to contain a libidinal element—a love of self that is in many ways comparable to the love of another individual). Nevertheless the concept has amply justified itself by the additional insight it has afforded into mental development, the psychology of individual differences and the nature of mental disease. We shall return to the subject a little later.

Here, however, we may perhaps remark in passing that narcissism, like auto-erotism, is never entirely outgrown; some degree of narcissism is, on the contrary, beyond all doubt, normal and essential. Further to make clear the difference between auto-erotism and narcissism, we may cite the case of a conflict between the two that is of frequent occurrence at the present day. When a woman refrains from indulging in some favourite but fattening dish lest she should endanger the slim silhouette that is nowadays so fashionable, a narcissistic impulse (the love of herself as possessing the desired-for slimness) triumphs over an auto-erotic impulse (which prompts her to enjoy the pleasures of the table).

The third stage is that of *allo-erotism*, or "object-love," in which libido is directed outside itself to some external thing or person. Its earliest manifestations are probably directed to the mother, as soon as the child begins to realise her existence as an external person on whom his satisfaction intimately depends; its fullest development is perhaps reached in the process of "falling in love" which is characteristic of adolescence and early adult life.

Development of the Component Instincts

Neglecting these distinctions for a while, let us return to a consideration of the development of the component instincts. On the strictly sexual side they can be studied in relative purity in those adults who exhibit the so-called *perversions* of the sexual instinct. These perversions are conditions in which the hegemony of the genital components has to a greater or lesser extent been replaced by a dominance of one of the other component instincts. Thus the so-called "voyeur" obtains his chief sexual satisfaction by looking (so that what is merely preliminary with others becomes an end with him), the exhibitionist by being looked at, the sadist by inflicting pain on his love-object, the masochist by enduring pain himself. Freud considers that the young child exhibits the germs of all the possible perversions, since there is as yet no genital hegemony and indeed little or no libidinal organisation of any kind. That is what he meant when he called the child a "polymorphous pervert." Though the term may be alarming, the concept is of real utility in affording insight into the essential continuity of the development of human sexuality.

Let us now consider some of the individual component instincts, with special reference to the displacements and sublimations that occur during their development. The oral stage (*i.e.*, as already explained, the stage at which the component instinct connected with the mouth is the most prominent) has left a deep mark on primitive human culture, a mark which is to be found even at the present day in such apparently diverse phenomena as the central rites of religion and the stories of the nursery. Eating is the most primitive manifestation at once of love and hate. For to incorporate by eating is the closest form of communion and loving proximity that is physically possible; and since the incorporated object is destroyed, it can also be a manifestation of hate (as witness the fact

that tearing with the teeth is the most natural expression of hostility in many animals). Hence the oral stage—especially in so far as it relates to biting rather than to sucking—is exquisitely ambivalent. The rituals of totemism, which constitute perhaps the earliest beginnings of religion, display this ambivalence very clearly. A primitive totemic tribe (or more strictly a certain section of the tribe) venerates a certain species of animal which it regards at once as a brother and an ancestor. As a rule the members of this tribe refrain from eating this animal, but occasionally it is eaten as a sort of ceremony; and this ceremony is, both psychologically and culturally, directly continuous with the theophagic communion services which distinguish so many of the world's religions,[1] and which in many cases clearly indicate both love and hate towards the god, who must be killed before he can be eaten. The god, as ancestor and father, sometimes retaliates by eating his children (as witness Cronos and Moloch), and when we come to the ancient stories that are still in use in the nursery (doubtless appropriately enough, if there is any truth in the doctrine of Recapitulation—a doctrine to which psycho-analysis has given valuable support upon the psychological side), we find that they are full of incidents of devouring by animals, ogres, witches or giants.

Scarcely less interesting, though perhaps less well established, is the influence of oral erotism on individual character. According to the evidence at present available, there would appear to be two fairly well-marked types of oral character. These types seem to depend upon whether the history of the individual in the early oral phase of life has been marked by contentment and confidence (that food will be forthcoming when required) or by discontent and anxiety. The former leads to a care-free, happy optimism. Like Mr. Micawber, individuals of this type always expect something to "turn up," and can thus look forward hopefully to the future, even when there is a shortage of good things in the present. They tend to be sociable, uncritical, and open to new ideas. Persons of the second type are apt to be hurried, impatient and pessimistic. They may be always asking, begging or demanding; or else—in order to guard against the threat of insufficiency—they may seek a career that offers safety (*e.g.* through provision of a pension) rather than advantages or prospects. In some instances they may unconsciously seek to revenge themselves for oral disappointments they have themselves endured, as in one remarkable case where a man of this type would invite his friends to dinner, and then absent himself from home, so that his guests were turned hungry away. In other cases hostility may express itself largely through speech, which has here become a displacement of the more primitive tendency to bite—a displacement, the nature of which is indicated by such common phrases as "incisive argument," "biting sarcasm" and "mordant wit."

The character qualities connected with anal erotism (*i.e.* the erotism of the component instinct connected with the process of defæcation) are so numerous and varied that they can best be stated in tabular form as follows:—

[1] *Cf.* Freud: *Totem and Taboo* (1919). See also the Article on *The Beginnings of Morals and Culture.*

	Displacements and Sublimations		*Reaction-Formations*
Retention	1. Postponement	Orderliness	28. Tidiness
Retention	2. Defiance	Orderliness	29. Organisation
Retention	3. Obstinacy	Orderliness	30. Pedantry
Retention	4. Miserliness	Orderliness	31. Clear thinking
Retention	5. Love of possessions	Orderliness	32. Thoroughness
Retention	6. Desire to collect	Orderliness	33. Punctuality
Retention	7. Dislike of waste	Cleanliness	34. Washing
Production	8. Concentration (especially after postponement)	Cleanliness	35. Cleaning
Production	9. Generosity	Cleanliness	36. Preventing accumulation
Production	10. Extravagance	Cleanliness	37. Fear of contamination (*e.g.* of self or " Nature ")
Production	11. Contamination	Cleanliness	38. " Purity "
Production	12. Untidiness	Cleanliness	39. Reality
Production	13. Noise (music)		
Production	14. Leaving mark } sadistic	Control	40. Strong will (resisting temptation)
Production	15. Destruction } sadistic	Control	41. Asceticism
Production; Manipulation	16. Speech		
Production; Manipulation	17. Writing		
Production; Manipulation	18. Painting		
Manipulation	19. Moulding		
Manipulation	20. Cooking		
Manipulation	21. Chemistry		
Manipulation	22. Photography		
Manipulation	23. Building		
Manipulation	24. Engineering		
Products	25. Child		
Products	26. Money		
Products	27. Papers		

Those qualities which represent direct displacements of original positive desires are placed in the left hand column, those which correspond rather to " reaction-formations " against these desires, on the right. Hence those in the right hand column often represent opposite characteristics to certain of those on the left.

The displacements of the original desires (left hand column) permit of being classified under four main heads :—

(1) Those connected with retention of the fæces—an act which is undertaken in the first place (*a*) in order to increase the eventual pleasure of the excretory act, (*b*) as one of the ways in which a very young child can show defiance of his nurse or mother. This process soon becomes associated with the idea of value attaching to the excreta (" products ") and hence, by displacement, gives rise to the desire to hoard and accumulate objects of worth.

(2) Those connected with the pleasure attaching to the excretory act

itself. These are of course, in certain respects, necessarily opposite in character to those of the previous group. Thus the desire to hoard or retain is contrasted with the desire to give (when associated with love) or with the desire to contaminate (when associated with hate—though of course ambivalence is frequent here).

(3) Those connected with the desire to manipulate the excreta when produced.

(4) Those corresponding to the simple interest in the excreta as valuable material.

If originally the act of excretion is a matter of pleasure and pride, and the excreta themselves objects of value and delight, under the influence of parents or nurses this attitude soon changes to one in which excretory acts are regarded as dirty or indecent, acts which must be sternly controlled and regulated. In this way arise the chief reaction-formations, which for the most part explain themselves.

A few brief remarks may be added concerning one or two of the individual items of our list.

Nos. 1 and 8 may be found together and manifest themselves alternately in an important type of anal character. The two traits together represent a displacement of the combined tendency, first to retain, and then to produce in large quantities. Such persons will, for instance, delay "action" (note the word) in important matters until the last possible moment, and may then become feverishly energetic and perform prodigies of work in a short time; or else they may refuse, for instance, to answer correspondence or pay their bills, until there is a great accumulation of arrears, to which they will then, however, devote themselves with fierce attention. Nos. 4, 5, 6, and 7 are, of course, usually found in combination with No. 26, which last is perhaps culturally the most important sublimation of anal erotism. Indeed there can be little doubt that a great deal of the economic basis of our present civilisation is supplied by this form of displacement. Nos. 14 and 15 represent tendencies the strength of which can be gauged by the difficulty encountered by the recent movement to preserve our parks and countryside from dirt and litter. The connection of these tendencies with anal erotism should be clear to anyone who will take the trouble to study the inscriptions to be found in almost any public lavatory. No. 25, which may at first seem strange, is due to the infantile theory of anal birth, a theory which is very natural in view of the child's ignorance concerning the functions, or even the presence, of the vagina.[1]

The known effects of urethral erotism, *i.e.* the erotism connected with the passing of urine, are far less varied and extensive. There is a certain amount of evidence to show that a highly developed interest in this process may be connected, at any rate in men, with the character-quality of ambitiousness. In its gradual displacements, the interest in question may lead to preoccupation with pipes and water, and thence to plumbing, hydraulic and electrical engineering (the latter owing to the unconscious

[1] It is very difficult to do justice to the complications of anal erotism in a few words. The student who desires a fuller treatment of the discoveries of psycho-analysis in this field should consult the relevant chapter in Ernest Jones' *Papers on Psycho-Analysis*, 3rd edition (1923).

equation of fire and water). But water in some form or other usually retains its attraction. Thus of the two cases of unusually marked urethral erotism which the present writer has himself had the opportunity of studying, one was a sailor, the other a keen swimmer.

Both sadism and masochism normally retain some importance in the actual sexual life ; to some small extent they must be regarded as constituents of normal love. Furthermore, in most people they remain potentially active throughout life, so that by appropriate stimulation they can easily be aroused in an intensity that borders on the " perverse " ; witness for instance the almost universal sexual attraction that is exercised by tortures and other " horrors." When such a perversion succeeds in escaping from control, it can of course become extremely dangerous, and may even manifest itself in " lust murders," such as those of " Jack the Ripper." It is frequently allied in a subtle way with anal erotism, and may then give rise to the actual practice of the phantasy of whipping. There are certain walks of life which would appear to offer good opportunities for the satisfactory sublimation of even high degrees of sadism—such as the professions of butcher and of surgeon. A more moderate degree of sadism can be utilised in many kinds of work ; but there are other professions where everything much in excess of the ordinary degree is socially dangerous, however satisfying to the individual himself—such professions as those of judge, magistrate, policeman or teacher. And these examples serve to remind us of certain very important aspects of sadism or masochism that have come to light in recent years.

We have already indicated how the mind possesses the power of arriving at a compromise between the forces of instinct and those of inhibition. This compromise is especially characteristic of neurosis, but is found also in conditions that would not ordinarily be called neurotic. In the examples that we have hitherto studied there takes place a condensation or over-determination which expresses both of two conflicting wishes. A slightly different form of compromise is one in which the inhibiting tendencies organised within the Super-Ego (*cf.* p. 359)—powerless to achieve a complete repression of the instinctive desires—permit some satisfaction of the instincts on condition that there be endured a certain amount of pain or suffering, as though by way of punishment to compensate the pleasure. Now the sadistic or masochistic impulses are peculiarly suited to enter into a compromise of this sort, for they can obtain their satisfaction by the very means adopted by the Super-Ego in exacting punishment. Hence it is justifiable to speak of a special class of " moral sadism " and " moral masochism." In moral sadism the impulses are directed outwards, and obtain gratification from punishing others who have allowed themselves certain forms of forbidden satisfaction. Our legal and punitive systems and our own social codes are full of instances in which society as a whole, or certain members of it, gratify at once their sadism and their moral indignation by punishment (often cruel enough, for most tortures—both of body and of mind—have been justified on moral grounds) of those who have offended against our legal, social or ethical codes. The same was true till fairly recently of our religious and educational systems. Now, fortunately, civilised humanity has achieved the great step of abolishing religious intolerance (though the abolition of political intolerance—in

some ways its modern equivalent—is proving hard to accomplish), while the moral-sadistic features of education are also tending to disappear. In moral masochism the impulses demanding pain and punishment are turned against the self, and may give rise to all sorts of discomforts, failures, self-deprivations and self-humiliations, the nature and extent of which psycho-analysts have only just begun to realise. The sexual element in these latter cases is often less easily revealed to superficial investigation. Nevertheless, it is commonly recognised that there exists a class of persons who " enjoy " their own sufferings, of which they will not readily permit themselves to be deprived. Such persons represent (within the range of the normal) extreme cases of moral masochism. We may suggest indeed that there are certain times and certain cultures which have been specially favourable to (or perhaps we should say, dominated by) such forms of self-punishment, *e.g.* the Middle Ages with their monkish and ascetic traditions, and to the modern civilisation of the Slavs.

The development of the somewhat analogous pair of component instincts known as scoptophilia and exhibitionism presents on the whole a somewhat simpler picture. A strongly developed scoptophilia may give rise to a generalised curiosity and love of spying and prying into others' lives or secrets; on the lower levels of displacement, the sexual background is often still discernible, and in the common forms of gossip, to which so many of us are prone, displaced scoptophilic tendencies will often fuse with moral sadism of the kind that we have just been discussing. In the higher forms of sublimation, scoptophilia would seem to play a most important rôle in scientific investigation, though even here some element of sadism may often co-operate. The scientific man " loves " his " subject," but nevertheless betrays a certain aggressiveness towards it, as he " wrests " or " wrings " its secrets from it.

The exhibitionistic instinct originally relates to the naked body, but in the course of individual development it inevitably (in civilised races) becomes displaced, to a greater or lesser extent, on to clothes. Clothes are, however, exquisitely ambivalent, inasmuch as they both cover the body and thus subserve the inhibiting tendencies that we call " modesty," and at the same time afford a new and highly efficient means of gratifying exhibitionism on a new level; as a successful compromise-formation they afford an interesting social parallel to many forms of individual neuroses.[1] In its simpler manifestations, as still attaching to the naked body, exhibitionism is often reinforced by skin and muscle erotisms, and these three combined play a large part both in sport and in the gymnosophist (" nudist ") movements of to-day. How strong and fundamental is this desire for nakedness, which we have retained in the unconscious from our childhood, is shown in the fact that one of the most general and typical of dreams reveals to us ourselves as embarrassingly nude or underclothed in public. In its more sublimated developments, scoptophilia may lead to the adoption of professions which involve playing a prominent and public rôle, such as those of the stage, the screen, the bar and the pulpit; while,

[1] The present writer has elsewhere endeavoured to trace in detail these hitherto somewhat neglected psychological aspects of dress. See *The Psychology of Clothes* (1930).

in its pathological aspects, it would seem to have a connection (at present but little understood) with certain skin diseases.

Turning lastly to the component instincts connected with the genital organs themselves, there seems little limit to the numbers of life's activities which receive at least some impetus from displaced genital libido—as is shown by the immense number of sexual (especially phallic) symbols connected with all kinds of objects and pursuits.

Two of man's great cultural achievements, however, stand out perhaps above all others as having derived the necessary energy from this source—the making of fire and the discovery and development of agriculture. We have already referred to the connection of fire and heat with sexuality, and, as to agriculture, we may remind the reader that the word "plough" is used in many languages to denote the sexual act, and that such terms as "seed," "fertility," and "barrenness" are applied indiscriminately to vegetation and to human beings. The widespread tendency to accompany agricultural ceremonies with sexual rites and sexual orgies again affords an anthropological corroboration of psycho-analytic findings. To mention just two other examples of genital sublimation, another, perhaps even more fundamental, instance is the use of tools, which are among the commonest of sexual symbols; while certain prominent philologists consider that the development of speech owes much to the deflection of sexual energy to this sphere, a contention to which psycho-analysts in their turn have brought considerable supporting evidence.

One further phenomenon connected with the genital instincts must be mentioned, because of its widespread influence and great importance. This is not (as in the other cases we have mentioned) a displacement of desire, but a reaction-formation, in the shape of anxiety lest the genital organs or their functions be harmed or interfered with. Arising in the first place, it would appear, as a fear of talion punishment for sexual thoughts or acts which have come to be regarded as guilty, this anxiety exerts a great influence in the unconscious minds of many individuals, where it constitutes what is usually called the "castration complex." In its typical form it is a male phenomenon, and attaches primarily to the feared loss of the phallus; but it may also occur in women, in whose case it leads to the belief that the phallus has been lost (and thence to serious feelings of inferiority). Indeed the anatomical differences between the sexes often play an important part in the origin of the complex. Normally, however, the ability to produce a baby seems to be the female psychological equivalent of the male's possession of the phallus. This is perhaps connected with the fact that the castration complex proper (as applying to the genitals) appears to be only a particular aspect of a general fear of loss of the means of satisfaction—a fear which is often connected with a whole series of earlier "traumatic," or shock-producing, situations, in which loss of the mother's womb (at birth), loss of the breast and loss of fæces all play a part. The precise significance of these last mentioned connections is not yet fully understood, but of the existence of the connections there can be no reasonable doubt. Finally we may mention that the castration complex appears to have a good deal to do with the development of phallic symbolism, since the use of objects which possess the requisite symbolic significance (often rationalised as means of protection

against "ill-luck" or the "evil eye") affords reassurance against the feared loss of the valued organ.

Narcissism and the Super-Ego

Let us now leave the individual component instincts to consider very briefly the more general development, through the stage of narcissism, to that of allo-erotism. In narcissism, as we have stated, the libido is directed to the self rather than to the outer world. Strongly narcissistic individuals can be recognised by their preoccupation with their own bodies and (at a somewhat more extreme stage) with their own minds. A very high degree of such narcissistic preoccupation makes the person in question relatively uninterested in, and independent of, the outer world; hence prevents the formation of the *rapport* or transference that is essential to all psycho-therapy. All forms of insanity imply some degree of withdrawal from the outer world. Perhaps the strongest impression that is received by any person visiting an asylum for the first time is one of surprise at the very little interest that the patients take in one another. Each seems immersed in his own concerns; there are no groups of two or three gossiping together, as there would be in a similar collection of normal people. In so far as the environment is taken into account at all, it tends to be reconstructed from within upon a delusional basis. Such persons have permanently lost their hold upon reality. All of us however have periodical relapses from contact with reality—in an extreme degree during sleep, and in a lesser degree during day-dreams and phantasy. In phantasy we achieve an imaginary fulfilment of our desires without the trouble of taking the necessary steps to achieve them in reality; in Freud's terminology, we are thinking according to the "Pleasure Principle" and not according to the "Reality Principle." This does not mean, however, that phantasy is necessarily useless. On the contrary it is probably essential:—(1) as an outlet or "safety valve" for desires that must inevitably remain unsatisfied in this imperfect world, (2) as a preliminary step towards actual achievement, for the fore-pleasures of imagination may act as a bait destined to lead us to the more toilsome, but more permanently satisfying, enjoyment of reality. It is only when phantasy withdraws an unnecessary quantity of energy from our dealings with the outer world, that it can be regarded as pathological; the diseases of phantasy are indeed only in the nature of misuse of that all-important faculty that man possesses for "looking before and after."

Apart from abnormal conditions, the nature of narcissism can perhaps best be realised by drawing certain comparisons. Let us compare first the mental states in bodily health and bodily disease. In the latter condition interest inevitably becomes more concentrated on the self; an ill man makes a poor lover. The difference in question is most strikingly illustrated by temporary troubles that appear and disappear very quickly, such as toothache or sea-sickness. In both states the sensations from our own body are so absorbing that they compel the withdrawing of our attention even from persons and things that were full of interest but a little while before.

As a second comparison, take the two sexes. Our present society expects and encourages a greater amount of narcissism in women than in men.

In women we cheerfully tolerate a degree of preoccupation with personal appearance that we should regard as foppish and effeminate (note the implication) in a man. In men's dress the note of display (for narcissism, in its social aspects, naturally exploits exhibitionism) is sternly suppressed. Even in the actual love-life itself there is a difference : a woman seeks to be loved rather than herself to love, but a characteristically allo-erotic man wants actively to possess himself of the loved object, and is somewhat indifferent as to whether he is loved in return. Of course the differences are in any case only relative ones. Men may also find certain substitutes for the personal beauty which is the goal of the narcissistic libido in women. Athletic prowess and muscular development may be such a substitute (a well-known exponent of physical culture tells his pupils that they will find their exercises " more interesting if performed before a mirror "). Intellectual prowess may also serve as a more subtle and sublimated substitute in both sexes, and this leads us naturally to the higher and more complicated developments of narcissism.

The earlier and more primitive forms of narcissism consist of love of oneself as one actually is. A larger or smaller amount of libido remains at this level throughout life. But, in the course of further development, a certain quantity of the libido originally entering into this form of narcissism undergoes displacement—and this in two main directions. On the one hand there is a displacement from love of self to love of others, *i.e.* a passage from the stage of narcissism to that of allo-erotism. To this we shall return in a moment. On the other hand there is displacement from love of oneself as one actually is (the real self) to love of oneself as one would like to be (the ideal self, Ego Ideal or Super-Ego—the same Super-Ego which, as we saw earlier, plays such an important part in the moral constitution of man). This displacement of primitive narcissism on to an ideal constitutes one great source of the energy whence our (often so fierce and overpowering) morality is derived. Another great source is more complicated in its origin. It comes from an introjection into the self of the earliest external moral forces, *i.e.* the moral attitudes and precepts of parents, nurses and other influential persons from whom the child first learns the distinction between right and wrong. By means of this introjection (or internalising) the individual comes in time, as it were, to carry in himself, as part of his permanent mental equipment, the moral standards of his environment. What were originally external sanctions have become internal sanctions. Recent studies in child analysis have shown that the foundations of the Super-Ego are laid at a very early age (certainly before five), and this to some extent explains the peculiarly archaic and inaccessible character of these foundations—which can be influenced only with great difficulty by subsequent experience. It is owing to this inaccessibility that man is, in Freud's already quoted words, " far more moral than he has any idea of," and that there are often (perhaps always) serious inconsistencies between the, generally more lenient, adaptable and " reasonable," morality of consciousness and the sterner and more inflexible moral elements in the unconscious—inconsistencies that are perhaps particularly striking in present-day individuals of advanced views whose theories are often far more liberal than their practice.

So stern and uncompromising is the Super-Ego that, though it undoubtedly depends to a large extent upon the introjection of the morality of our elders, it would nevertheless seem that there must be further factors at work in its formation, especially since there is by no means always an exact correspondence between the severity of the Super-Ego and the actual sternness of the parents. This is one of the great problems with which psycho-analytic research is grappling at the present moment. Our knowledge is not yet advanced enough to state anything with certainty, but it appears as though at least one important factor lay in the recoil upon the self of the individual's own aggressive tendencies. These tendencies are called up by any frustration of desire, and are at first directed outwards. We act as though all frustration were due to an intentional hostility on the part of those about us (much as the savage still thinks that ill-luck, disease and death are all due to black magic or to hostile spirits). But, since we both love and fear our elders, this aggressivity due to frustration must be itself inhibited, and thus frustrated; and it would seem that all inhibited aggressivity must either find another outlet (through displacement—as when the clerk, who has been angered by his employer, vents his wrath upon the office-boy), or else be directed inwards against the self. In very early life alternative external outlets are difficult to find; the aggression therefore returns upon the self and constitutes one of the chief sources of the savage and cruel aspects of the Super-Ego.

In so far as this theory is true, we can see how even exceptionally mild and indulgent parents may yet be instrumental in forming a stern Super-Ego in their children, for such parents are peculiarly unsuited as objects on which to direct a fierce aggression; hence the greater necessity of inhibiting this aggression and its consequent greater likelihood of turning back upon the self. We can see too that the problem of an over-stern Super-Ego is not necessarily solved by the mere substitution of kindness for severity in the nursery and in the schoolroom. The problem is more difficult than that. Possibly the solution may lie in a combined method of diminishing frustration (by a more tolerant attitude towards the " polymorphous perversion " of the child—an attitude which should be the nursery equivalent of a greater social leniency towards the sexuality of adult life), combined with the provision—where possible—of suitable outlets for such aggressivity as is still inevitably aroused. This is as yet little more than speculation, but it is clear that the problem is one with which the further development of psycho-analysis will soon bring us face to face.

Let us now return to more established aspects of psycho-analytic theory. The nature and function of the Super-Ego, as conceived by analysts, cannot be fully understood without a reference to certain further concepts elaborated by Freud in his book *The Ego and the Id*, published in 1923. Here the mind is divided into three parts, termed the *Ego*, the *Super Ego* and the *Id*. The Ego is that part which is concerned with the perception of outer reality and our adjustment to it, while the Id is the great reservoir of instinctive energies from which all our desires are ultimately derived, but for which we do not always consciously hold ourselves responsible (hence the term [the " it "], which indicates that we

tend to regard it as something foreign to our *selves*, as when we say, "I was carried away by my emotions," or "I was overcome," by them). The Ego has a hard task, calling for much strength, skill and diplomacy, inasmuch as it has to do its best to satisfy three masters, to wit, outer reality, our instinctive desires located in the Id, and our moral standards located in the Super-Ego. In mental disorders, the Ego has proved unequal to this task (though the actual nature of its breakdown varies with the nature of the disorder), and the aim of psycho-analytic therapy is to strengthen the position of the Ego. This involves : (1) an uncovering of the Id, so that the true nature of the (repressed) instinctive desires is revealed, (2) a no less free examination of the nature and demands of the Super-Ego, and (3) a breaking down of such neurotic compromise functions as have been arrived at between the Super-Ego and the Id. Both Super-Ego and Id have therefore equally to face reality, and to make the sacrifices that may be necessary in order that the human energies locked up in the conflict may find a free expression in reality, *i.e.* in order that our desires may receive the maximum of "real" gratification in a way that is in harmony with the claims of rational or enlightened morality. The essential difficulties, as we are beginning to realise, lie in (2) and (3) rather than in (1). As regards (2), it may be safely said that every successful resolution of a neurosis involves some modification and relaxation of the claims of the Super-Ego, which is often just as unwilling to take account of the realities of human nature (*i.e.* the fundamental and ineradicable nature of the instinctive urges), as the Id itself is unwilling to take account of the obstacles that the outer world so often puts in the way of our desires. Above all, it must give up certain archaic features of its constitution, such as :—(*a*) the tendency to punish thoughts with the same severity as actions (as when a person treats himself as though he were actually guilty of the death of a relative, whose death he may unconsciously have desired, but which he has done nothing whatsoever to bring about), (*b*) the tendency to extend the condemnation of a specific desire to all desires remotely associated therewith (*e.g.* to condemn all sexuality because the first expressions of infantile-sexuality had an incestuous foundation). But perhaps the biggest difficulties lie in (3). A neurosis of long standing represents a peculiarly stable compound of the forces of the Id and of the Super-Ego, which is hard to break up because both sides fear to lose by a resolution of the compromise. To use a social parallel, the satisfaction which the Super-Ego and the Id derive from the neurotic symptoms is like that which the Churches and the bootleggers alike find in Prohibition, and which renders both sides equally unwilling to consider objectively the possible benefits of a repeal of this restriction upon liberty.

It is a curious and interesting fact that, so far as psycho-analytic investigation has yet gone in the study of the Super-Ego, it seems to show that our troubles—both individual and social—are due much more to the excessive, than to the deficient, morality of man. In fact, no single analyst has as yet reported a case in which the Super-Ego of his patient seemed dangerously weak. This somewhat paradoxical finding is largely due to the fact that an excessive development of the Super-Ego, with consequent extreme efforts at repression, prevents the displacements and sublimations of the libido that accompany "normal" development.

The libido therefore remains fixated at a relatively crude and infantile level, and in a sense, therefore, really tends to express itself in actions that would be regarded as improper or immoral if judged by adult standards. A vicious circle is thus set up; repression induces fixation, and this in turn gives rise to fresh efforts at repression. The only cure for such a condition is a relaxation, and not a tightening, of the moral censorship. Indeed, many anti-social acts, which might at first seem to indicate an unduly feeble Super-Ego, are clearly traceable upon closer examination to the influence of the Super-Ego itself. Among such acts are: (*a*) the "crimes from conscience," to which, as psycho-analysis has shown, certain persons may be driven, in order that the consequent punishment by society may replace and alleviate the intolerable tension of internal guilt; (*b*) the deeds of hostility and revenge prompted by the inevitable resentment occasioned by a too deep and constant frustration of vital instincts; (*c*) the direct expressions of libidinous tendencies that are permitted on condition that they are paid for in terms of suffering; (*d*) the cruelties that result from a projection on to others ("scapegoats") of this need for punishment. This last case, as already mentioned in another connection, usually exhibits a strong admixture of sadistic trends. It undoubtedly constitutes a source of aggression of a socially very disruptive kind, into the amazing strength of which we are only just acquiring a dim insight.

Object Love

Leaving this difficult and comparatively recent chapter of psycho-analytic theory, let us in conclusion deal briefly with the third stage of development—that of object love or allo-erotism. Freud has drawn up a short scheme of the chief means of transition to object love, which is perhaps worthy of quotation here. According to this scheme there are six chief ways of acquiring a love object:

Narcissistic Type, in which love is directed to:	1. What one is. 2. What one was. 3. A part of oneself. 4. What one would like to be.
Anaclitic Type, in which love is directed to:	5. The mother who nourishes. 6. The father who protects.

In the first four cases the transition to object love is *via* narcissism. The term "anaclitic" (literally "leaning up against") means that in the first phase of their existence the outwardly directed elements of the libido prop themselves, as it were, upon the self-preservative instincts and thus become directed to the persons who satisfy the latter instincts.

No. 1 is the simplest form of object choice. It represents a simple displacement of primitive self-love (love of the "real" ego) to love of others, according to the principle of similarity. Thus, quite generally, we tend to love those who are like ourselves, whether the resemblance be one of intellect, character, moral standard, social class, racial type or physical characteristics (as when, for instance, as statistics indicate is on the whole

the case, tall men marry tall women, and vice versa). One particularly important aspect of this type of choice is that which leads to homosexuality, for a person of one's own sex is in certain important respects more like oneself than is a person of the opposite sex. Connected with this is the fact that a homosexual object-choice is very frequently found in association with a strong element of narcissism; heterosexuality seems to demand on the whole a further general advance of the libido in the direction of allo-erotism than does homosexuality.

No. 2 depends upon the fact that the narcissistic libido often undergoes a fixation at a certain stage of the development of the individual concerned, usually the stage at which he (or she) still possessed the physical charm of youth and beauty. Such an individual then remains permanently in love with himself, as he was at the particular age concerned (a fixation which indeed seems sometimes actually to prolong the youthful appearance of the individual). When fixated narcissism of this kind is displaced on to another person, it chooses as object a person resembling the lover as he was at the age at which the fixation took place. It may thus give rise to pæderasty. But it may also operate in a more subtle manner, as when a woman sees in a young man just those elements of " boyishness " which she herself has inevitably lost to some extent at puberty, when she acquired the special characteristics of her own sex.

No. 3 is the special form of narcissistic object love that characterises the love of parents for their children, who may be regarded as constituting (almost literally—especially in the case of the mother) a part of themselves. It is in virtue of a displacement of this type that a very narcissistic woman may become a loving mother, even though she may have shown herself capable of but little affection towards her husband (who is unable to attract the narcissistic libido in this way). Parental love, however, seems only to be the extreme case of a very general tendency to regard everything on which we have lavished toil and care as, in a certain sense, an extension of our own personality. The attitude of the collector to his treasures, of the inventor to his invention, of the writer to his book will naturally occur to the reader in this connection. Indeed the labour of an author in producing his work has often been compared to that of a mother in giving birth to her child.

If No. 1 corresponds to the displacement of that portion of the narcissistic libido which attaches to the " real ego," No. 4 represents the displacement of that portion which attaches to the Super-Ego. It is this element which, beyond all others, accounts for the (as it so often seems to others) absurd over-estimation of the loved object by the lover, who often considers himself all too unworthy as compared with the virtues of the person on whom his adoration falls (just as his real ego is " unworthy " as judged by the standards of the Super-Ego). In its more specific workings, this type of object love may lead to the choice of an object who possesses different or opposite qualities to those of the lover, the loved person thus representing a " compensation " for just those qualities in which the lover himself is deficient (corresponding to a projected form of that compensation for " organ inferiority " which Adler has emphasised in dealing with the individual). This type of love may therefore exhibit opposite characteristics to those of No. 1.

Types 5 and 6 are more generally understood outside the ranks of psycho-analysts themselves, and therefore may be dealt with very shortly; for, ever since the early days of psycho-analysis, the Œdipus Complex has occupied the foremost place in all discussions of the subject.[1] It must suffice here to remind the reader that one of Freud's most fundamental discoveries concerned the vastly important rôle of the father and mother as the earliest objects both of love and hate. The myth of Œdipus, who kills his father and marries his mother, represents the translation into adult terms of the primitive tendencies of the boy child who has realised that his father is a rival who prevents his own (the child's) monopolisation of the mother's time and love. A similar attitude *mutatis mutandis* is characteristic of the little girl, though in her case the development is rather more complicated, inasmuch as her very first love-object is the mother, just as in the case of the boy. Indeed, in the case of both boy and girl, the attitude toward both parents is to some extent an ambivalent one, though in normal development love goes preponderatingly towards the parent of the opposite, hate to the parent of the same sex as the child. But all possible combinations of love and hate are to be found, from the fully developed " normal " to the " inverted " Œdipus Complex. In this latter form of the complex, the boy (usually as a means of avoiding the otherwise inevitable hostility with the father) identifies himself with the mother and seeks to love the father in her place, so that she, rather than he, becomes the rival—the girl of course behaving correspondingly. This inverted Œdipus Complex is another important factor in the production of a homosexual object-choice.

The original love and hate embodied in the Œdipus Complex undergoes extensive and important repression and consequent modification and displacement. Hate is often to a great extent repressed and concealed by love, though it may throughout life influence character through various unrecognised displacements. Love itself undergoes repression through the very strong taboo of incest, which is one of the most remarkable features of human society at all levels of development, and the influence of which can be traced in the various exogamic rules and practices which distinguish so many primitive peoples. As a result of this repression there is brought about a certain dissociation between the sensual elements of love upon the one hand and the elements of tenderness, devotion and respect upon the other—a dissociation which is of the greatest importance for both social and sexual life (especially in the male sex), but of the true nature and causes of which we are still far from having a complete knowledge.

Only second in importance to the child's attitude towards his parents is his attitude towards his brothers and sisters. Here too there is a general arousal of ambivalent emotions. A younger brother or sister is often at first looked upon as a rival, though (especially if there be some considerable difference in age) quasi-parental feelings of love may also be engendered. These feelings of love are in their turn subject to repression at the hands of an incest taboo which is but little less severe than that operative between parents and children.

[1] A full treatment of the theme in all its ramifications has been attempted by the present writer in his *Psycho-analytic Study of the Family* (1921).

A great deal, both of individual character and social culture, depends upon the gradual displacement of the various loves and hates aroused within the circle of the family. Here we can only indicate in barest enumeration some of the most important forms of this displacement.

A strong parent fixation in persons of either sex may manifest itself in an inability to marry or leave home, or a failure to achieve reasonable self-reliance and independence of character. The actual displacement of parent-regarding feelings may take place along lines of relationship (*e.g.* from father or mother to brother or sister, uncle or aunt, cousin, etc.), age, name, character, general situation, etc., *i.e.* any one of these factors may act as the mediating association of a displacement. A particularly important instance of the last mentioned type occurs when a repetition of the original Œdipus situation, in which there was an obstacle to the child's love, is sought as an essential condition of later loves. In such cases, a love without external impediments is unattractive and a person is capable of sexual attachments only to, say, engaged or married individuals of the opposite sex. So frequently is this tendency present in some degree or other that it seems to form the ground of the very widespread appeal of the "triangular situation" in literature and the drama.

In successful "normal" development there takes place a gradual "weaning" from the parents and the parental situation, so that ultimately the individual is free to live and love in ways that have but little reference to the original family situation. Entire freedom is, however, in all probability impossible to achieve, for analysis can nearly always reveal some association with the parents, who were the original objects of love, fear and hatred. Thus, in our attitude towards social groups and institutions, the same influences are operative as in the case of our attitude to individuals. The individual's love for his country is largely tinged by its association with his father or mother ("Motherland" or "Fatherland"), as is also his love for his native town, his school, his church ("Mother Church"), his University ("Alma Mater"), and even his "mother tongue." The enemies of his country are treated as though they were would-be ravishers of his mother, while to those who hold positions of authority within his own group he displays the same ambivalent emotions of love and hate, of veneration and impotent rage, that he once felt towards his father. Politics indeed represent little more than a reliving and re-enactment of the infantile attitudes aroused in connection with the Œdipus Complex, and, until this is understood, there is small hope of human conduct in this field becoming more rational and more adjusted to reality.[1]

A few final words on certain further effects of fixation at the Œdipus level must bring this Article to a close. When the fixation on the parents is strong, the child may be unwilling to abandon the exalted idea that he has formed of the power, knowledge and goodness of the parents; the real parents, when he comes to understand that they also have their deficiencies and limitations, are very disappointing when compared with the magnificent beings that he had imagined them to be. This may give rise to the very widespread "foster-child phantasy," according to which the child himself is a changeling, who has lost his true parents and been

adopted by others, who are inferior to them in wealth, station, character or power; a phantasy which has found expression throughout the ages in "the myth of the birth of the hero," in which the young hero, the son of gods, princes or nobles, is brought up by animals or peasants. Moses, Perseus, Romulus, Lohengrin, are a few among the very many legendary heroes of this type, while Mowgli and Tarzan of the Apes represent corresponding figures from modern literature.

But the most general of all methods of dealing with this persistent longing for the ideal parent is to project him into the heavens as a deity; for gods and goddesses are the omnipotent parents of our infancy, permanently enthroned in their high estate. By this act of projection the adult human being saves himself the painful realisation of the fact that he is ultimately dependent on his own efforts, and is enabled to retain the infantile notion—to which we would fain all regress in time of trouble—that there is somewhere a watchful and loving parent who is ever solicitous for our welfare. But the gods can be angry as well as kind, and this aspect of deity corresponds to the hostile and (especially in the higher religions) to the moral aspects of the parents. God, as judge or avenger, fulfils much the same functions as the Super-Ego, and may be described as the external equivalent of the Super-Ego. The punishments, sacrifices and ascetic practices demanded by God are similar, in their general intent, to those demanded by the Super-Ego, and are inspired by much the same feeling of guilt.[1] How strong is this feeling, and the consequent need for an avenging God, is shown, for instance, by the inability of organised Christianity to remain contented with the more purely positive and loving morality of its founder. The attitude implied by Christ's words, "Neither do I condemn thee," leaves unsatisfied the "need for punishment," which is as important a feature of religion as it is of neurosis. Christ's attitude demands a freedom from guilt and hatred, which only a very few elect minds here and there have been able to achieve, and the attainment of which on a large scale is possible, if at all, only by a general understanding of the neurotic and quasi-neurotic elements of guilt, which psycho-analysis alone would seem to be in a position to bring about. As long as there is serious fixation at the level of the infantile attitude towards the parents, it would seem almost inevitable that there should be, not only dependence on the parent substitutes (which merely makes us helpless and unprogressive), but also hate towards them (which makes us cruel as well). That the attitude of humanity towards its gods is deeply ambivalent can be shown by any thoroughgoing analysis of religious belief and ritual, but especially by an analysis of sacrifice, which has as its ultimate motive the slaying of the god himself, and is thus a repetition of the prototype of all great crimes—parricide. A religious or social attitude based consistently on love would seem to be possible only in so far as the hatred, and consequently the guilt, associated with our infantile reactions to the parents, have been generally outgrown.

We have finished our survey of psycho-analytic theory. This theory is already so complex and has a bearing on so many fields, that much has necessarily been left unsaid, and much has had to be presented in a

condensed and somewhat dogmatic fashion. But it is to be hoped that we have at least made clear the great importance and interest of the subject. If, in conclusion, it be asked, what is the bearing of psycho-analysis on human culture as a whole, the answer would seem to be, that it holds out the promise of enabling us to become more conscious of ourselves, and thus to extend our powers of rational insight and control. The biological value of conscious mind lies in its capacity for delicate discrimination and adaptation. The unconscious instincts and reflexes by which our lives, like those of other animals, are so largely determined, doubtless have great value for rough orientation towards our environment. But they tend to work on the " all or none " pattern, and are incapable of those finer adjustments of means to ends, which, when organised and co-ordinated in physical science, have enabled man to win an altogether unique power over Nature. But this power is itself a danger unless it is accompanied by a corresponding knowledge and control of our own selves ; which alone will enable us to use this power for beneficial, rather than for harmful and self-destructive, ends. The psychological and social sciences are, it is universally admitted, in a lamentably backward state as compared with those other sciences which deal with our physical environment. In psycho-analysis man would seem to have an instrument with which to readjust this balance, and thus to become master in his own house, as well as in the outer world.

THE BEGINNINGS OF MORALS AND CULTURE: AN INTRODUCTION TO SOCIAL ANTHROPOLOGY

By

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SYNOPSIS

Anthropology, the science of Man, divides into Physical and Cultural branches that are severally concerned with body and mind; and of the latter, while other sub-divisions deal with handiwork and language, the most important section is Social Anthropology, namely, the study of moral institutions and ideas. As for method, any enquiry into the historical development of morality must start from the instincts; must thence go on to observe how reason supervenes on instinct to lend conscious direction to the process; and, finally, must show by reference to the facts how conduct conforms to the change of control involved in this substitution of intelligence for blind impulse. Now the instincts, though the biological function of all alike is to promote the survival of the species, fall into two main classes, according as they either directly subserve group-maintenance by way of mating, nursing, and herding, or indirectly do so by enabling the individual to achieve self-maintenance through self-protection, self-assertion and self-sustenance. When man's instinctive endowment is thus analysed it turns out that, as compared with other animals, he shows no deficiency in this respect, but on the contrary has so many of these predetermined tendencies that in practice they would conflict and hold one another up, were it not that the resulting instability affords intelligence the chance of bringing experimentation and choice to bear on this wealth of possibilities. At the primitive stage of society, however, intelligence has but shaken off the tyranny of instinct to succumb to that of habit. Morality is of the customary type. Externally viewed, it depends on a law, religion and education that insist on rigid conformity to convention, a sort of tribal drill. In its internal aspect, again, the moral judgment involved is uncritical, conscience amounting to a mere orthodoxy, and even the leaders of opinion depending rather on subconscious inspiration than on reflection. A review of the actual moral codes of savages illustrates this dependence on ready-made standards of right and wrong. As

the instincts can be distinguished as group-maintaining or self-maintaining, so the moral activities can be classified as making either for sociality or for personality. Under the first head come domestic, tribal, and inter-tribal forms of organization regarded as attempts to establish closer and wider relations between human beings naturally associated by blood or by local contiguity. A one-sided family life and narrow clannishness gradually evolve into a more or less well-disciplined tribalism capable of certain courtesies towards strangers. But savage society gets no further than this, imposing as it does too uniform and fixed a set of rules on its members to provide scope for the variability and initiative on which the possibility of a higher culture rests. Under the second head, however, fall agencies that help to build up a moral personality of a rudimentary type, so that both manliness and godliness come to serve as ideals on which the individual may model his life. Such manliness is pictured chiefly as the power of cutting a brave figure in society. The godliness, on the other hand, is more clearly conceived as a state of the soul; but primitive religion is more successful in prescribing negative obligations in the form of abstinences than in enjoining a positive scheme of good behaviour. Even so, though it does little to clarify morals, it greatly helps to heighten morale.

THE BEGINNINGS OF MORALS AND CULTURE: AN INTRODUCTION TO SOCIAL ANTHROPOLOGY

INTRODUCTORY

Adjacent Fields of Research

All distinctions are drawn at a venture, and even the distinction between Physical and Cultural Anthropology—in other words, between Man's body and his mind, together with the things into which he has put his mind—is not quite so radical as might be supposed. It is not a question merely of those cultural adornments that become more or less permanently attached to the body, such as the tattoo-marks of a savage or the civilized man's false teeth. In so far as our bodies take outwardly or inwardly the impress of our habits, or, in biological language, in so far as concerns acquired as opposed to inherited characters, the anthropologist of the body has to consult his colleague, the anthropologist of mind and society; and in practice, whatever may be the case in theory, it is hard to prevent an overlap between the two kinds of work.

Next comes another set of distinctions, also difficult to determine exactly, that fall within the sphere of Cultural Anthropology and enable it to be broken up into sections employing each its own appropriate methods, and its own body of special students. Thus Technology, which deals with the products of the human arts and crafts, whether useful or decorative in their intention—in a word, with what is known as Material Culture—forms one group of studies. A second comprises Linguistics, which examines the various speech-forms of Man considered apart from their literary outcome; the latter topic being treated as the affair of the third group. This remaining section, by far the most comprehensive of the three, is known as Social Anthropology. It is with it alone that we have to do here.

Before proceeding to consider it in detail, however, two further points about classification must be noted. The first is that General Anthropology, as it may be called, embraces all the topics already mentioned. So far as it tries to use their several results in combination—as notably when it tries to account for the Distribution of Peoples in the light of their racial peculiarities, arts, languages, and social customs, regarded as one and all contributory to their ethnic or national individuality—such investigations may be termed ethnological in scope; and in this sense General Anthropology may be said to culminate in Ethnology. It goes no further, however, because it is not a Philosophy of Man, but only a Science of Man based as directly as possible on his Natural History. It is, in fact, simply a highly specialized and developed branch of Biology, the science of living

nature in general, of which Man is in a way a small part; though it is the part which he wants to understand most and on the whole has the best chance of understanding, having an inside-view of himself and of no other creature.

The other point is that both General Anthropology and its various subdivisions draw freely on other sciences which, though to this extent subsidiary, occupy more or less independent positions of their own, such as Geology, Physiology, Psychology, and so on. Of these the two most immediately concerned with Anthropology are, perhaps, Prehistoric Archæology, which is especially helpful to Technology, and Anthropo-Geography. The latter describes the human Environment—which forms with Race and Culture a triad of basic conditions that Anthropology assumes to be together responsible for the making of Man. It only remains to add that, while every anthropologist firmly believes his science to apply to mankind in general, it is only with the more uncivilized kind of man that he is at present free to deal as he pleases. So far, the enquirer who tries to take a biological and therefore universal view of human history has no weight with or control over the student of civilization; who, treating culture of the Western type as an ultimate fact, is consequently bound to mistake his relative for absolute values. It is for the future to adjust the focus better—to decivilize history, as it were, in the sense of humanizing it more impartially and completely. Here, however, in accordance with existing custom, only primitive man will be considered—primitive, that is, whether in the sense of old or in that of old-fashioned. For, as the French put it, there is a modern as well as an ancient prehistory. Pre-history of course only means pre-literary history; and fortunately there are other historical documents besides books—harder to decipher, perhaps, but sometimes less lying.

Scheme of Enquiry

If a student, for worthy or unworthy reasons, wanted to acquire the rudiments of Social Anthropology at short notice he might be advised to give his mind to two topics, Social Organization and Religion, the study of Institutions and of Beliefs; and to leave the rest, the Economics and Law on the one hand and the Ethics and Aesthetics on the other, to fit in as best might be contrived. This means that one can broadly distinguish between the external forms in which any human society displays its activities and the inner meanings and purposes on which the activities in question ultimately depend. Man being what he is, and always has been as far as our backward view extends, namely, a social animal, we have a right to posit as our datum-fact the human society rather than the human individual taken by himself.

To ignore the individual, however, as the sociologist is apt to do, losing sight of the trees in a wholesale but blurred contemplation of the wood, is fatal to a true understanding of our dealings with one another. For the gregarious habit has its limits. The struggle for existence proceeds, in however mitigated a form, within each society; while the strength of the social bond would seem, in turn, to depend largely on the support that it gives to each co-partnership in a fiercer struggle waged with the rest of humanity. Whether, however, we base the human society on mutual need

for purposes of common self-assertion and self-protection, or insist rather on the consciousness and love of kind which certainly helps to foster such association, the fact remains that for the historian the unitary human agent whose activities he studies is not this man or that, but a group of men forming some sort of body politic and more or less in charge of their own affairs.

Given, then, such a society, it will inevitably have a structure, just as if it were really and not metaphorically a body; while, to pursue the same analogy, there will be functions corresponding to the structure. Like the body, then, the social organism will likewise exhibit processes of feeding, breeding, fighting, maintaining health, recuperating by means of rest, and so on. In terms, then, of such a morphology and physiology of the body politic, we could stop short at describing all the outward manifestations of the social life. It would be as if one were to visit a foreign country without knowing a word of the language, and were nevertheless to draw up a description of the visible behaviour of the people. Yet clearly such an account would be very imperfect. Another traveller, who was at home with the language, would double or rather treble its value by supplying the motive—the more or less conscious why and wherefore—of everything that was done.

In short, a Social Psychology is needed to supplement the mere surface-view of the life of any given people. For Man is not only the social animal but the self-determining animal above all others. The ultimate clues to his actions must be sought within himself, whatever the behaviourist may say. Indeed, a behaviourist philosophy which would explain life exclusively in terms of matter and motion is either physical science gone mad, or, more probably, it is sheer narrowness of education. Here, at all events, the human universe will be viewed as if its true centre were the human mind. What may be broadly termed morals will be treated as the clue to the social life in the sense of the outward manifestations of the pursuit of good. The sources of human character will be examined as it realizes itself in and through human conduct. It only remains to add that, since we are concerned with mind as something that develops, we are bound to cast back some way into the sub-conscious or even unconscious. It would be fatal to forget that the social mind—so far as one can talk of such a thing at all—has also this side to it. As a branch of biology, anthropology is bound to interpret the history of human intelligence as an evolution proceeding gradually from unconscious instinct on and up towards conscious reason.

So much, then, for the scope and method of the present enquiry. A. We shall start with a search for the human instincts. B. We shall next try to discover how, thanks to the intervention of conscious purpose, they are converted into moral sanctions. C. Finally, the ensuing conduct will be considered in sufficient detail to bring out that moral quality which is the only true test of the degree of culture, or self-cultivation, therein achieved.

A. THE RAW MATERIAL OF MORALITY: THE HUMAN INSTINCTS

Man has had moral freedom in sight ever since he emerges into history. Primeval instinct may retain some slight hold over him, but it has none of

that absolute grip to which the rest of the animal world is subject. The blinder the response to stimulus, the lower the rate of individual survival—such is the law of the evolution of life. Instinct merely ensures that what is done is often enough right to maintain the given kind in being, whether one in ten or one in ten million be lucky enough to hand on the torch. Intelligence, on the other hand, stands for economy in the spending of vital energy. For it implies that, whereas the function of Nature is still to hint that one path for all lies ahead and common rules of the road must be followed, nevertheless considerable discretion is left to each wayfarer to pick his own steps. At most, then, our racial inheritance consists in a vague sense of direction together with a certain ability to keep going along this line. The rest is, broadly, a matter of free choice. Instead of instincts that would master us, we have impulses that act as our servants, at any rate so long as we are in a fit state to rule, and are not in the plight of those sick souls that cringe to some overpowering passion.

An impulse can be recognized by its emotional tone, which preserves the primitive character displayed at the level of animal instinct. Thus, suppose a man to be suddenly startled, he will feel afraid; but he will probably, at the same time, feel curious, or perhaps angry, or else submissive. All these emotional reactions to the situation reveal the presence of so many expert assistants, each of them ready to carry out instructions in his special way at the bidding of the will; so that the man will run away, or draw near, or fight, or grovel accordingly. For the psychologist, then, the analysis of the emotions probably offers the most effective means of classifying our instinctive tendencies; which such a method proves to be many and complex. Here, however, it will suffice to group them more roughly by reference to their function of providing morality with its raw material. Now we have a social and an individual side to our life, but it would seem that it is only through sociality that moral individuality can be achieved; so that for our present purpose the social aspect should be given priority.

Correspondingly, then, we may arrange the human instincts under two main heads, according as they are more directly concerned with the claims of others or with those of self. One can think of them as the instincts that severally subserve co-operation and competition; but it must be remembered that they are there, not to pull against each other, but to pull together, since all alike have been evolved as instruments of racial survival.

(*a*) *Group-maintaining Instincts:*

In the first group, then, are the instincts relating to group-maintenance, which can be considered under the three heads of mating, nursing, and herding. Of these functions mating and nursing—in other words, reproduction and the care of offspring—obviously go close together, but have to be distinguished inasmuch as, at a lower grade of organic life, the one can exist without leading on to the other. Now just as sexual reproduction is the most direct means of securing the continuance of our species, so it is the most powerful and all-pervasive of the human instincts; and it hardly needed the testimony of Freud and the other psycho-analysts to remind us of so insistent a fact.

To a corresponding extent, then, the history of morality must largely turn on various steps taken to regulate this primal urge. Instead of perpetual freshets and floods, an orderly flow of this mainstream of the passions can be brought about only by the most elaborate canalization. So uncompromising and severe are the sanctions that from time immemorial have repressed illicit forms of love, that the horror excited by the occasional violation of these ancient taboos has come to seem almost natural, that is, instinctive ; whereas the never-ceasing sense of strain attending a controlled sexuality is enough to remind us that habit, though reputed a " second nature," can never amount to an altogether effortless rule. It is only fair to add, however, that the theorists are by no means agreed as to the precise point at which the line is to be drawn between the instinctive and the habitual, the natural and the artificial, the animal and the purely human. Thus it is still a burning question whether a repulsion against close inbreeding is congenital or, on the contrary, an effect of early marriage-custom. For the rest, we are probably entitled, on the strength of various analogies drawn from other animals, to include in the sex-complex certain incidental tendencies, of which jealousy, modesty, and self-display are leading examples. It remains, also, to note that sex-instinct in Man is by no means to be treated as a constant, since its intensity varies with age and perhaps, to some extent, with season ; while there is reason to suspect that vigour in this respect as between the different human stocks is not always the same.

Next, as regards parental instinct, we may take its strength, and more especially its duration, as a fair measure of superiority in the matter of organic development. It is to be noticed that the two parents play different, and not always equally onerous, parts in the maintenance, protection, and education of their young ; the animal world providing cases in which the male, or more rarely the female, is relatively remiss in regard to such duties. In this connexion it should be noticed too that the impulses to breed and to nurse are so far independent that, just as a hen will bring up alien chicks, so there is a type of human society in which brothers bring up their sisters' children to the utter neglect of their own.

Finally, the herding instinct, though involved to some extent in any form of family life, may be treated as something specific, inasmuch as there is a marked difference between the solitary and the gregarious types of animal species. Curiously enough, the man-like apes, to which the biologist is most inclined to turn for his clues to the very early history of Man, are decidedly prone to form small rather than large groups, such as find favour with other members of the simian tribe, as, for instance, the baboons. It has been suggested that the decisive change occurred when man became a meat-eater and thereupon found it expedient to hunt in packs like the wolves. But it is quite doubtful whether he has ever done so. On the contrary, the unitary human group of effective common life may always have tended to be small at the hunting stage of society, when it normally takes many square miles to feed a few. Be this as it may, mankind must all along have enjoyed a group-life sufficiently intense to afford expression to impulses that make either for greater solidarity, such as self-subordination and self-devotion, or else for better understanding, such as imitation, suggestibility, sympathy and, in a wide sense, concerted

play. Given, then, all these propensities naturally disposing men to draw near to each other, one chief task of morality was to organize them so that they should work together for good, as far as the moral life consists in co-operation.

(*b*) *Self-maintaining Instincts :*

In the second group are the instincts relating to self-maintenance, and these can likewise be treated as threefold, according as they are concerned with self-protection, self-assertion, or self-sustenance. It is for the racial advantage that each individual, however social in his disposition, should likewise be able to shift for himself, and to some extent at the expense of the less able and worthy; but on the other hand these instincts, though primarily self-regarding and competitive, exist ultimately for the good of the species as a whole no less than do those which immediately further group-life. Self-protection is clearly the biological purpose of the fear-instinct, which in the opinion of the psycho-analysts is exceeded only by the sex-instinct in the power of its grip on the human organism, to judge by the violence of its effects in the case of the mentally dissociated. A remarkable feature of the fear-complex is the number of specialized reactions which it comprises. Thus, one may be moved either to run away or to keep still in the presence of danger; while many minor phobias have been distinguished, each governed by its own form of terror. Indeed, it it a nice question whether the anthropologist may not look for an inherited as well as a purely traditional element in the fear almost universally excited by particular kinds of objects—blood, corpses, snakes, and so on, the strongest case being perhaps that of ghosts. Yet, however different they may be in other respects, these experiences agree in being " *asthenic,*" that is, literally, strengthless, involving a lowering of the vitality, a sinking of the heart, as if a reinforced weakness were Nature's reminder to be prudent.

The self-assertive type of instinct, on the other hand, such as anger or pugnacity, has the opposite function of heartening and bracing. Nevertheless its association with fear is very close, since it needs some sort of alarm to set the counter-attack in motion; and indeed the most timid of animals will put up a good fight if brought to bay. It is to be noted, moreover, how intimate is the connexion between the fighting instinct and the rivalries of the mating season—a point which well illustrates how an apparently self-regarding disposition is really of racial service. As compared with other animal types that are better armed in respect of tooth and claw, Man would not seem to be in general suited to gain his ends so much by brute courage as by cunning; though there is reason to think that considerable differences in regard to inborn fierceness exists in various human stocks that have severally adopted aggressiveness or submissiveness as their leading rôle; for both are ways of survival.

It remains to notice the self-sustaining type of instinct, which in its most fundamental form is concerned with nutrition. One hardly knows whether to postulate greediness, or fastidiousness, or the recklessness begotten of sheer hunger, as the natural cause that turned Man into a carnivore, or, rather, an omnivore with carnivorous leanings. In any case he has seemingly been hunter long enough to have acquired a specific

hunting-instinct, which is distinguishable from the fighting-instinct by the accompanying emotional tone, though in many respects akin to it. Whereas anger pivoting on fear is the characteristic note of pugnacity, the hunting temper subordinates ferocity to an acquisitiveness united with curiosity, thus involving a certain play of the intellect such as underlies the sense of sport. Instead of merely seeking to drive away or destroy, the hunter is out to assimilate. In place of anger, his disposition involves a kind of love and interest, even if it starts as a mere cupboard-love, a pregustatory interest. Indeed, since animal analogies show hunting to be associated with collecting and storing, the acquisitiveness thus bound up with hunting, or at any rate with nutrition, is evidently at the root of the property-feeling; and thus plays an all-important part in the building up of human culture, seeing that culture on its material side is simply a hoard of properties. It has only to be added that self-sustenance is the biological end of the whole health-preserving process covering exercise, cleanliness, and sleep, and we have brought to an end our review of the organic capital laid up, as it were, beforehand for the human being to spend at his own discretion—and risk.

In a sense, it is a very rich endowment. We have so many instinctive tendencies that in practice they inhibit one another, and give the will the chance of throwing its weight on this or that side of the balance. Human conduct, regarded in a broad historical way, is anything but natural. On the contrary, it always seems exceedingly arbitrary, not to say odd; and we should rejoice in the fact, because eccentricity and individuality are twins. We have broken away from Nature regarded as the sum of the blind impulses pushing us along from behind. Rather, we trust to a forward-reaching faculty that depends more on hope than vision; and are engaged in a campaign of experimentation on so vast a scale, that every petty people has diverged into habits of its own on which it stakes its very existence. Thus, at the far end of the historical process we clearly discern an animal of uniform type which differs from the rest only in being somewhat over-endowed with instincts and to a like extent unspecialized and unstable. Yet, at the near end, represented by the present, we find the lineal descendant of that same animal enjoying an amazing variety of experiences; out of which, were he as wise as he is ingenious, he might surely select the make-up of a good life.

B. THE MORAL SANCTION: CUSTOM

In escaping from instinct Man might seem, at first sight, to have but fallen into the hands of another and a worse tyrant, namely habit. For a habit is, in a way, an accidental precipitation, and hence a limitation, of an instinct. The first reaction that happens to occur tends to repeat itself, with the result that other possibilities of impulsive response are suppressed. Thus, one of the firmest postulates of the psycho-analysts is that some single experience in very early childhood may produce a persistent emotional bias; so that, for instance, a life-long horror of cats may result from one infantile encounter with an aggrieved kitten. So too, then, accident has left many traces on the history of human society. Moreover, whereas individual habits are not transmitted to the

next generation, social habits—in other words, customs—can under primitive conditions have an almost age-long duration.

Such continuance, however, depends on some sort of disciplinary system which brings a steady pressure to bear on every member of the group. Apart from it he would have no such social habit at all, and despite it he is ever ready to deviate from the average line of conventional conduct. It is but slowly that society learns to distinguish between deviations for the worse and deviations for the better, and to this day no sure criterion exists for differentiating the reformer from the criminal. Early politics being petty but desperate, a life-or-death affair, no risks are taken, and a premature martyrdom is apt to overtake the innovator, not to say the genius. Travellers who know the savage well do not find him by any means lacking in originality; but they universally testify to the strictness of a social code which recognizes but one type of behaviour as incumbent on all.

We have, then, in a word the character that marks off primitive from advanced morality, when we say that the former is customary. Right or wrong for the savage is simply as custom decrees. It makes little difference whether one considers the matter from without or from within. Not only are the traditional rules enforced in their entirety, but likewise in their entirety do they feel and seem obligatory to everyone involved. These two aspects of the moral sanction, the external and the internal, are worth examining at greater length.

(1) *External Aspect*

Externally viewed, the moral discipline to which the individual savage is subject from the cradle to the grave depends on a social organization, an established scheme of co-ordinated activities. As when a boy joins his school, or a young man his regiment, the new recruit is faced with a curriculum, a drill, to which he must outwardly conform whether he likes it or not. At first he is almost bound to resent being licked into shape, especially as the licking is not all done by means of the tongue. His natural plasticity, as it were, registers an inward protest against the stiffening that is relentlessly exercised by the mould. In time, however, there steals over him a sense of inevitability that ripens into a positive acquiescence in a set of rules, the real purpose of which may even now be scarcely understood. If anyone has a clear idea of the meaning and value of the whole set of arrangements, it will be the authorities, the elder folk, in charge; but they in their turn have been through the mill, and, in proportion as they are supine and stupid, will be content to carry on in a mechanical way. A test of the relative intelligence with which they perform their duties of instruction will be the extent of their reliance on persuasive as contrasted with purely coercive methods. Obviously they are likely to convince just in so far as they can show reason for what is done. It must be noted, however, that the reason implicit in morality is as much an affair of the heart as of the head. Unlike logical reasoning which, at least in appearance, moves forward, ethical reasoning always looks back in order to justify something that all along has been more or less self-evident, namely, the goodness of the good life.

A great deal, then, of the desirability of any orderly mode of social existence needs no explaining any more than does the swing of a good dance; and, so long as it goes with a swing, one kind of dance is almost as satisfying as another. The trouble is, however, as we have seen, that in social no less than in individual experience accident has a way of twisting and cramping the play of natural impulse, so that it is difficult to recover from bad tricks that have been picked up at the outset in some casual and almost insensible fashion. Thus the function of reason in morality is largely the negative one of purgation; for it is only by realizing that the tricks are not part of the style, but on the contrary are so many impediments and contradictions that interfere with the pleasant rhythm of the social round, that men slowly accommodate their concerted actions to one of those relatively equilibrated systems of controlled impulses which are healthy and therefore happy. Now no savage society has yet acquired any considerable power of self-criticism, so as to expurgate its customs by reference to its own dominant notion of good. Though it may be vaguely aware that it has got into bad ways, it cannot break with them because it has not yet learnt to look them in the face; for, if once they have been brought into manifest consciousness, they can be mastered. Thus it took civilized society a long time to face the evils of slavery, despite all its skill in clothing its sentiments in articulate language. How much more difficult, then, must it be for a body of savages to rid itself, say, of human sacrifice, however loathsome and burdensome such an institution may proclaim itself to the feelings of all, so long as it is not seen for what it is in itself apart from the salutary elements of the religion with which it is confusedly associated? In what follows, then, our chief interest must be to note how far intelligence enters into the social drill—in other words, how far the reason for the rules prescribed is given together with the bare order to conform.

(*a*) *Law*

On its purely coercive side, custom is equivalent to what an advanced society knows as law. What Bagehot calls " the persecuting tendency " is alive in every human breast, as a boy at school soon finds out if he departs from the ways of the majority. Moreover, every crowd follows its leader, so that there will always be some whose authority, however indefinitely exerted or recognized, governs the actions of the rest. Again, a human society is a crowd which remains in being through constant recruitment on the part of the newly born, who during their long pupilage are bound to find their leaders among the elder generation. Some sort of parental discipline, in fact, is the natural beginning of law; and indeed family jurisdiction remains an important branch of legal procedure throughout the incipient stage of its evolution. So early, however, is the age at which the lesson of obedience is learnt in the savage home, that within its purely domestic range primitive morality is apt to seem almost automatic, and punishment is rarely administered or required.

Nevertheless, within the domestic group, which tends to be a one-sided affair consisting of the mother's people or the father's people—the former system being presumably the earlier—there are fundamental laws to be observed, such as notably three:—to avoid sexual relations

with group-mates; to avoid killing them; and, if they are killed by outsiders, to kill these in turn. These three laws of the blood are so engrained in the moral nature of the savage that one is tempted to overlook their social origin; which must be traced back to very ancient insistence on the domestic proprieties, possibly on the part of the mothers whose blood was the symbol of social decency and honour. Nor need we suppose that any mercy would be shown to the rare offender against the laws of the blood, a moral leper whose unclean presence was intolerable.

On the other hand, outside the domestic circle were other groups with which less sympathy would be felt, since the ties produced by intermarriage would be offset by vendettas and other sources of quarrel. Thus when any sort of tribal organization involving a central authority comes into play, a far greater difficulty is experienced in bringing the pack to heel, and the situation demands a more liberal use of the whip. It is in fact a case of fighting down the tendency to fight among themselves, and this is rarely accomplished without the interposition of strangers who impose social order in their own interests in the form of servitude—an unwelcome discipline on which all civilized peoples must, to some extent, look back. Hence, it is not until tribal society, with its more or less loosely organized system of kin-groups on one social level, gives way to the class-system which is characteristic of a nascent state, that a strong and centralized law comes into force. Up to that point such punishment as is publicly enforced may mostly be treated as a by-product of religion.

(b) Religion

In a way religion may seem just as coercive as law, or even more so, inasmuch as its prohibitions are backed with threats that take the form of curses. Such curses, moreover, are wont to take effect palpably and at once, since primitive society, in order to avoid universal pollution, is prompt to rid itself of the offending member by a sort of surgical operation. Thus, humanly as well as divinely regarded, a sin is even more deadly than a crime. The real sanction, then, of custom in the early society is that it is largely sacred. It is unforgivable to do anything likely to bring ill-luck on oneself, because ill-luck is catching. There can be no arguing about the utility of a taboo, namely, an avoidance resting on a religious sanction. It is unconditional—something that simply cannot be done. Even when a man is punished for acting in a way that is obviously prejudicial to the public advantage, the savage is apt to invert the reason for his fate by supposing that he must have brought a curse upon himself or he would never have behaved so badly. This sacrosanct character which attaches to tribal usage, entailing a ceremonial punctiliousness that extends to the last detail, affords the true explanation of that conservatism which the civilized man who comes into contact with the savage finds so unreasonable, because it rests on no plain grounds of common sense.

It is easy, however, to overlook the fact that primitive religion is not all negation, but has its positive side. To observe taboo is to enjoy *mana*, namely, spiritual power, or strong-heartedness, an equally infectious thing. So long as the group can feel that its collective luck is intact, it

is sure of itself. Call *mana* morale, and one can see how spiritual welfare is more important than temporal welfare to hard-pressed folk ever on the edge of starvation, whose native pluck is their one permanent stand-by. Thus the old-world community is not wholly to be blamed, if it finds the adoption of improvements, pressed on it by some alien culture, about as hard as it is for a civilized church to alter its prayer-book. The root-feeling is a sort of veneration for the ancestral wisdom and piety that have made the people what they are, that is, what they would like to believe themselves to be. Their theological justification for such a sentiment may be rather mixed, conceived as it is likely to be in terms of totems,[1] ghosts, nature-spirits and so on. But the quantitative effect of the moral sanction is in direct ratio with the qualitative, because the social rule is infinitely more binding when the tremendous import of the divine is superadded. Savage faith—or, as some would prefer to say, primitive credulity—is strong; so that, for instance, an oath is no vain form, but suffices to turn a human trial into what our own Middle Ages called a "judgment of God." A secular law may always be dodged; but there is no dodging a conviction of sin. Indeed, nothing is wrong with the spiritual armour of the savage except that it is inelastic.

(*c*) *Education*

Whereas coerciveness is a leading feature not only of law but likewise of religion at the primitive level, since on the whole it might be said to lay more conscious stress on the fear of taboo than on the hope of *mana*, there are also gentler influences at work that more or less persuasively inculcate good behaviour. As for the moment we are considering the moral sanction on its external side, we can ignore all that the individual picks up for himself, living as he does cheek by jowl with his fellows and taking part in everything done or suffered by the rest. Teachers, however, are not wanting to school him in his tribal duties. Until the age of puberty, as a rule, nothing systematic is attempted in this way, and more is learnt in imitative play than from the direct injunctions of parents and kinsmen. On the other hand, when as often the initiation ceremonies are of an elaborate and prolonged character, the novice undergoes a disciplinary course that is calculated to make a man of him at any cost to his private feelings. In Australia, for instance, apart from a good deal of terrorism, conjoined with symbolic rites intended to promote bodily growth, there is no little instruction of a doctrinal kind in all that pertains to tribal lore.

It is to be noted that these tutorial functions are exercised, not by the youth's own kinsmen, but by the males of the group into which he is destined to marry, who thus make sure that he is worthy of such an alliance. Incidentally, this give-and-take between the kins in the matter of the training of the young shows that one and all are being taught to take more than a domestic view of their moral duties, and, in a word, to feel and think tribally. It is no wonder that, when with advancing years they play an increasingly prominent part in these and other solemnities, the more intelligent acquire a good working knowledge of all the niceties

[1] See Glossary, p. 430.

of the customary code. Thereupon they proceed to sit with the rest of the experts on more or less formal councils which, though largely administrative, would seem occasionally to introduce changes amounting to fresh legislation.

Moreover religion, even when of the rudimentary type, does not entirely lack the individual note; and the inspired man is permitted to indulge in innovations that militate against ritualistic stagnation. In fact, in its small way tribal life keeps the mind busy with affairs that, if carried out without much discussion of principles, are nevertheless so immediately before the eyes of all concerned that their bearing on the general welfare is never in doubt. In savage society one does not need to think much about a duty that stares one in the face. At the same time, too, one's neighbours are only too ready to point it out, if they deem it necessary to do so.

(2) *Internal Aspect—The Pre-ethical Conscience*

To suppose that the savage has no sense of right and wrong is, of course, an absurd mistake. He is inwardly guided by standards that, in a way, have all the more hold upon him because they are uncritical and unreflective. In the orthodox man " the native hue of resolution " is not " sicklied o'er by the pale cast of thought." He is secure in his judgments and correspondingly vigorous in his actions until a new situation finds him unprepared, when all becomes confusion. It is notorious how utterly a primitive community becomes demoralized if suddenly forced to change its customs. To the average member of the static type of human society there seems to be only one possible way to behave. He has never tried to analyse his moral system into its elements, so as to discover their separate values apart from context; and so he cannot distinguish between principles and details. Since therefore he cannot pick and choose in the bestowal of his appreciations, which extend indifferently to everything sanctioned by convention, he may be said to lack moral freedom.

It is but just to note, however, that this is hardly needed, inasmuch as no free career lies before him. As Maine puts it, he is subject to a regime of status as opposed to one of contract. His duty is to live according to the station to which he is born, not to go forth experimentally to seek whatever station will accord best with his opportunities and merits. In a dynamic world, then, a man has to invent a moral character, whereas in a static one he has simply to imitate one. The savage, as it were, finds his part ready written for him; so that his business is but to render it correctly and not to " gag." Consequently, any departure from custom offends his moral sense, very much as a child dislikes hearing liberties taken with the words of a well-known story. Moreover, primitive orthodoxy is essentially a crowd-consciousness, and it is hard to resist the feeling that whatever everybody says and does must be right. The only glimpse that the savage gets of another point of view under a clan-system is through marriage into another kin, which at all events has probably another totem and a few ceremonies of its own, though one and the same general level of outlook prevails throughout. Morals, in short, amount to hardly more than tribal good manners. To do what is not done is the mark of the impossible person, who being strange is

unclean—unless, indeed, something superlatively forceful in his exceptional behaviour causes him to be accounted holy instead.

Wrong, then, in the savage eyes is more or less equivalent to taboo. It stands for everything and everybody that a plain man should shun. The standard by which it is judged is intuitive and almost æsthetic. It is a matter of good taste to recoil from anything so immediately offensive to the well-bred. It must be kept at a distance because one cannot touch it and remain pure, that is, a healthy member of the community. Since social health is identified with unanimity, the toleration of something alien must act like a spreading sore. Loss of conviction will entail loss of confidence, and the savage society that has lost its nerve is doomed. Indeed, there is here to be noticed a sort of echo of that herd-instinct which expels the sick or wounded beast. It is unsafe to live with it, and this is enough to condemn it. So too, then, savage justice takes little account of motive. Whether by his own fault or by sheer misfortune the offender has done something whereby he forfeits his right to associate with the rest. No excuse can alter the fact of his infectivity. Nay, he may already have conveyed the taint to his immediate surroundings, so that he and his alike will have to be banned.

As for right, on the other hand, this means for plain folk to be respectable—to stand well in the public favour. The man in the crowd may almost be said to think of himself in the third person, so much does he apply a crowd-judgment to the figure which he cuts in society. Of this exterior self he is exceedingly conscious, but of the intimate self within hardly at all. His moral personality is worn like a garment cut to the fashion, and he is uncomfortable in proportion as he feels untidy. Contrariwise, a sense of being well-dressed is the very secret of his strength. He hardly counts it suffering so long as it makes for a braver show. His ambition is to live in style—to be in the centre of the picture.

It must be remembered, however, that in the static type of society the appearance is in close keeping with the reality, since there is little to do which cannot be copied. There may even be a sort of intensive progress achieved by constant efforts to improve on the same model. A heightened morale will inevitably result if everyone strives to shine in the eyes of his neighbour. After all, much human energy is dissipated in making frequent changes, and it may well be that the more conservative type of human society has more gusto to throw into its untiring repetition of the familiar. The very sacredness that is imputed to the ancient and traditional would seem to indicate that old acquaintance is needed to stir the deeper feelings; and, if a certain shallowness be observable in modern civilization, it may be because the pace is too fast. The moral experience, then, of the ordinary savage is not shallow in the sense that it fails to touch a deeper self in him, but in another sense it is, because this is a generalized, collective self—one that imposes the same set of repressions and liberations on all alike without regard to the variable element in human nature. It may be that savages breed more true to type than happens in the civilized society that is composed of many racial strains. Even so, though to wear the conventional self may afford sufficient play to the average man's nature, it is decidedly hard on such misfits as occur.

It remains to consider the psychology of the leader of a primitive

society; and this presents peculiar features. Among those who exercise more or less authority over the rest we can distinguish two classes which might be termed lay and religious. The first of these, which is altogether less important or even typical, is composed of those who simply represent the flower of the conforming majority—those who have made themselves conspicuous for bravery, liberality and whatever other virtues are generally admired. In a way these men of high average attainments form the very backbone of the tribe. And yet it is not to them that their society is apt to turn at times of crisis; for their strength lies in dealing with the normal.

To the second class belongs the type of man whose pre-eminence rests on a claim to supernatural power—*mana*. The two classes shade off into one another only in so far as any outstanding merit or success carries with it promotion from a lay to a spiritual status. *Mana*, however, is conditioned by taboo—by a precautionary withdrawal from the common pursuits of common folk. Broadly speaking, a man's holiness is proportionate to his remoteness. He must reserve himself for critical occasions, if he is to intervene convincingly when nothing but a miracle will save the situation. Thus he has a chance of developing a mentality differing from the crowd-consciousness of his fellows. By virtue of his social position he is thrown back on himself—introverted; while probably he is likewise, by his natural bent, disposed to be a dreamer. William James in his *Varieties of Religious Experience* has attempted to analyse the state of mind of the civilized visionary; but neither Christian saint nor Hebrew prophet can compare with the savage seer in respect to the obscurity of his thought-processes, which barely emerge above the level of the subconscious.

Especially hard is it to frame a moral estimate of the character that goes with this high-strung kind of temperament. From the standpoint of common-sense it is decidedly suspect, fluctuating wildly as it does, so that now it seems inspired but now fraudulent, now reaching towards the divine but now descending to the devilish. It may be then that the extreme cases serve mainly to impress the crowd and render it submissive, and that the real leaders of society are rather the men in whom ecstatic gifts are less in evidence than is a capacity for state-craft. Even so, the mere profession of sanctity entails a certain isolation that is favourable to self-communing and hence to the development of individuality. Leadership goes with independence of mind such as is denied to those who have no inner life.

C. THE WORKING OF THE SANCTION: MORAL ACTIVITIES AND VIRTUES

Our final task—and one that, if carried out in any detail, would take us far—is to examine the effects on human conduct and character of a morality of the customary type. We are trying to extract from the historical facts some answer to the question—What kind of good is to be got from a life that is ruled mainly by habit? A rational ethics suitable to a modern society might not be prepared fully to endorse Clifford's paradox, "It is not right to be proper"; but it would certainly go far toward

encouraging a critical attitude toward current practice and opinion, for the purpose of distinguishing principles of lasting value from the accidents and whims of the moment. At the same time, our world finds it hard to devise a system of moral education that will produce the good man who is at once broadminded and of strong character, because the heart lags a long way behind the head in adaptability, or, in plain language, emotional as contrasted with intellectual tendencies are inelastic if once they become set.

The savage, on the contrary, has no need to think about his duty, because the sentiments drilled into him early in his life can be trusted to last him to the end of it. He has the negative strength of the narrow-minded—a sort of obstinacy. He cannot die alone for a new principle, but he can die with his fellows for the old country and its old ways. His tragedy is that, brought suddenly into contact with a dynamic world which has little sympathy for his slowness, he must perforce be the martyr of a lost cause. Nevertheless, he is not an animal, with instincts that must literally be rebred in him if they are to be changed. He is a man with a culture, the artificial product of an education that must be constantly renewed if the culture, and through it the man, are to survive. His education differs from ours only in so far as it offers the individual the choice of only one kind of moral personality. It is a one-pattern system of tailoring. Fortunately human taste is so various, not to say arbitrary, that every little community the savage world over has struck out something characteristic in the way of a style; so that it is, indeed, mostly because it is the heir of the ages that civilization has become so diversified a bazaar of fashions.

For the moralist, then, human culture is primarily an educative process, and it is in this light that we must here consider the advantages and shortcomings of a customary regime as illustrated by savage life. As the instincts were found to fall into separate groups, according as they chiefly had group-maintenance or self-maintenance for their biological end, so it will be convenient to distinguish moral activities, together with the corresponding virtues, under a like pair of heads, according as they mainly serve to foster sociality in the group or personality in the individual. The raw stuff of which human nature is composed consists of these two threads; and, however much they may intertwist, education, which is as it were the dyeing process, allows the difference between them to appear in the finished article.

(1) *Activities making for Sociality*

(*a*) *Domestic Virtues*

The social life in a sense embraces all living humanity, not to speak of the other dimension in which it extends from our ancestors to our descendants. Within this somewhat indeterminate tissue of inter-personal relations, forming what might be termed the body of morality, all our collective activities take shape round a number of lesser centres. Thus, everyone belongs to some sort of body politic which provides him with his unit of social reference. Within this nucleus, however, there is always to be found a nucleolus or core of intenser sociality, the very hearth and nursery of the group-maintaining instincts. We can call this the home

circle, since, as will presently appear, the term " family " has to be used in a rather unfamiliar way if it is to cover all the facts.

Here, then, we have the groundwork of a triple classification of Man's social activities, according as they are domestic, tribal, or inter-tribal. We can think of every individual as ringed round with these three concentric spheres of duty towards his neighbours, who experience the warmth of his charity in a declining ratio at each remove of distance. To reduce these three degrees of social sympathy to one must be the abiding hope of ethics. Yet, since morality is more a matter of quality than of quantity, this can only be done, not by substituting a correct but cold cosmopolitanism for the old affection felt towards home and country, but on the contrary by promoting moral individuality, so that each member of the constellation should, as it were, throw out more heat for the benefit of the entire system. Charity must always begin somewhere, though it need not end there ; and for this reason the touchstone of the moral condition of a given people is best sought in the quality of its home-life. Without intimacy, there can be no love.

How, then, are we to conceive the earliest kind of home ? Do what one will, one cannot prevent history tailing back into pure mythology, and science can but see to it that facts and inferences are kept distinct. At most, then, we can frame a fairly accurate notion of the general conditions of human life in Europe for, say, the last twenty millennia, a matter of about a thousand generations—quite a short span if reckoned in terms of biological process. This northland type of man, fire-using, tool-making, cave-dwelling, was in culture already a long way ahead of forebears who must have surely picked up the rudiments of living humanly, or at least sub-humanly, under far easier conditions of climate, when they could camp in the open and find a sufficiency of animal, or at any rate, vegetable, food at all seasons. Dense forests would not suit their habits so well as rather open country, such as would likewise favour wandering and dispersal. The size of the separate bands would depend on the food-supply, and it is in economic terms that one must chiefly calculate the strength of the social bond. So long as gathering prevailed over hunting, in which department a more or less weaponless man can do little on an effective scale, the females of the group would be economically almost independent of the males ; and, if they had fire, they might even largely dispense with their protection. On the other hand, their child-bearing and nursing functions would render their life more sedentary than that of the men-folk, especially after the latter had progressed in hunting skill and become addicted to the joys of the chase. Nor need it be supposed that the claims of sex would permanently enchain the males, so long at any rate as mating was mainly governed by season. On the contrary, one might suppose that breeding-time would be the moment when intestine rivalries would periodically threaten to shatter the usually placid intercourse of what was primarily a " syntrophic association," in other words, a food-group.

Thus it is probably quite wrong to imagine the primitive horde as essentially a harem owned and guarded by an ever-jealous patriarch—a sort of Grand Turk. With just as much, if not more, right could one compose a myth of Amazons who are economically self-sufficient enough

to be able likewise to retain the initiative in the bestowal of their favours. Using their authority as mothers to stop in the young what they could not so well prevent in the old, they might at length succeed in putting their ban—one might almost say their curse—alike on mating and fighting within the home-circle. Given the proximity of more or less related and friendly bands, there would be no great hardship in obliging the young men to go abroad on amorous visits, especially when once it was understood by their neighbours that the compliment could be returned. Be these guesses sound or not, human society as we know it can provide examples of a well-established type of domestic communion in which only one parent is represented, namely the mother. Supported by her brethren, she manages her children without the father having any say in the matter; for he is but a stranger from over the way, just as her own brethren are strangers to the women with whom they go forth to consort.

Thus the basic principle of such a household is that those who feed together must not breed together—that sex is a disturbing factor that must altogether be suppressed within the home. It is usually known as the law of exogamy; but the term is not very happy in that it seems to render the rule as "Marry out," whereas its real import is, "Avoid incontinence within." The absolute stringency of the taboo may be taken to argue for its great antiquity; while the fact that incest is universally regarded as an offence against the sacred blood constituting the mystic bond of kinship points to its origination in the kind of group of which the breeding women formed the rallying-point and centre—in a word, stood for home. Since savages are still to be found who do not understand the physiological side of fatherhood, it is a fair assumption that in early times the mother would be credited with the entire responsibility for the child; while not only childbirth, but other mysterious incidents in the life of woman, would serve to make her blood at once a great taboo—a source of disaster for the heedless—and a thing full of *mana*, the natural symbol of the collective being and luck of the group.

Now, taken in its purely negative capacity as a rule that prohibits interbreeding between group-mates, the law of exogamy displays complete indifference as to what sort of sexual relations are formed outside. There is nothing in what it prescribes to prevent sheer promiscuity so long as it is confined to dealings with strangers. On the other hand, it might be assumed that sexual selection would not fail to operate in some degree; or, in other words, that individual mating preceded by some rude sort of courtship would prevail, even if it by no means follows that the ties thus formed would last for life. For exogamy merely implies that one can mate with any stranger, not that one must mate with all strangers without distinction. In short, it indicates one's "marriageables," not one's actual spouse; so that the theorists are wide of the mark who would deduce an original promiscuity from the wide terms in which an exogamic marriage-licence is cast. On the whole, we can but suppose that the duration of the union would depend on the amount of cohabitation involved. A more or less furtive assignation in the bush, or a liaison contracted in the course of some collective visitation of the youth of the other camp—for such saturnalian invasions occur to this day, and, as we hear from the Trobriand Islands, it is not always the young men only who thus

go forth to conquer—could create no real partnership, no joint interest in a common hearth and home; whereas an attachment involving residence with the woman's group, or at any rate assistance rendered to it in the shape of presents of food and so on, would ripen eventually into a firm union.

In the existing societies that practise the extreme forms of mother-right[1] this kind of "labanism," or marriage by service on the part of the husband from without, is already for the most part in vogue. As in each group life becomes gradually differentiated, so that each woman with her brood tends to have a fire and shelter of her own, and perhaps a gathering-ground destined eventually to become a hoe-patch—for agriculture almost certainly starts as the woman's business—there will be a corresponding appropriation of the husband's services to the particular needs of the wife and her family. As soon as he helps to minister to her private necessities, his domestication has begun, and the claims of their common home begin to outweigh the duties that he owes to his kin. His kinsfolk for their part, however, long continue to regard him as having no right thus to rob them of their time by pandering to the wants of aliens; and, if he does, are apt to require compensation for the labour that he has put into his wife's house or plot of ground. In such minds the very notion of the family as a bi-parental affair has scarcely yet taken shape.

It remains to note a consequence that is liable to disturb the peace of a group organized as a motherhood, if the stranger is tolerated as a visiting squire of dames. What if mother and daughter compete for the attentions of the same man, or he for his part uses his opportunities to throw over an older woman for a younger? A rule that lovers must not look beyond their own generation will clearly make for group solidarity, and, however it may have come about, can be discerned at the back of the taboo of the mother-in-law—the most rigid of those avoidances which accentuate the separateness of all who marry under the law of exogamy. Whereas sexual relations between kinsfolk are offences against the blood, this does not hold of intimacy with the mother-in-law; and yet this too is reckoned incest—a fact which incidentally proves that it is not instinct, but social convenience, that is the real sanction of these fundamental prohibitions. That "marriageables" must belong to another kin, but to the same generation, are roughly the two clauses of the exogamic law, covering every kind of inter-sexual connexion from a casual flirtation to a partnership for life.

Hence we find Australian tribes who label themselves according to what is known as the four-class system, which uses different names, firstly for alternate generations, and secondly for the inter-marrying sections of each of the pair. Thus of every four women a man knows at once by their class-names, while conversely a woman knows about every four men, that only one is a possible mate, namely, the one belonging to the opposite section of the same generation, while the other three are immediately recognized as ineligible. It is worth repeating, however, that this does not in the least mean that the cross-sections of any one generation are promiscuous in their relations. It would be just as absurd to infer that we are promiscuous within the limits indicated by the table of

[1] See Glossary, p. 430.

prohibited degrees in the prayer-book. Marriage within a class and marriage by class are utterly different things; and the chances are that when Aristotle described Man as a "pairing animal" he was not far wrong, however much the savage may be inclined to repeat, and thus multiply, the pairing process.

A great revolution came about when somehow kinship came to be reckoned as relationship on the father's instead of the mother's side. It is pretty certain that the change was not due to a recognition of the physiological function of the male, because there are patrilineal peoples in existence whose theory of how babies come is still on a par with nursery tales such as that the storks bring them, or that they are found under the gooseberry bush. On the other hand, the chances are that relationship at first implied physical contiguity—in other words, being born and bred in the same local group. Whenever, then, it became the custom for the males to bring home their wives, allowing their sisters to be similarly carried off to strange camps, there would really be very little point in distinguishing the children by the separate group-names of their mothers; at any rate unless these connexions with outside were allowed to override their prime duty, which is obviously to support their own daily companions.

Even if it be granted, then, that the earliest kins were at once matrilineal and matrilocal as the only way of accounting for the facts that blood-relationship and the blood-avoidance involved in exogamy relate primarily to the mother's blood, it might well happen sooner or later that a sort of revolt of the man might occur, whenever mating had come to necessitate enough cohabitation to make service with strangers altogether too onerous. If, for instance, there were a great disparity in numbers and strength between neighbouring groups, the male members of the more powerful one would be sorely tempted to make their brides come over to their own side where food and protection were more easily to be obtained. Having once asserted their authority in the form of wife-capture, they would retain it in any wife-exchange that was almost bound to ensue, since under the new system their sisters had still to be provided with mates; and, after a longer or shorter period of mixed nomenclature during which the children lived with their fathers but retained the kin names of their mothers, the paternal group-name would be adopted as alone suitable to express the social unity that comes of living together and acting as one body.

It might seem, indeed, that at this point a bi-parental family ought to come into existence; so that henceforth the child should be recognized as belonging more or less equally to both sides of the family. To some extent such a result would actually seem to follow, and we often hear of cases where the father and the maternal uncle alike exercise an authority which, however, is never so much joint as rival. It depends on the closeness of the relations between the various kins, how far interference with each other's concerns is tolerated; whereas, if they remain more or less mutually independent and even hostile, it is clear that a son must make up his mind whether he pulls with his father or against him.

There is, indeed, a moral principle deeply engraved in the savage mind that stands directly in the way of the possibility of anything but a

one-sided family under any system organized on the basis of kin. This is the duty of blood revenge. Two laws of the sacred blood have already been considered, which forbid the violation of its purity by either marriage or murder—the two abominable sins of the early world. But there is a third law hardly less cogent, namely, that of wiping out the alien shedder of kin-blood. This is not a taboo but a positive injunction, and therefore perhaps involves a slightly more conscious attitude than that of recoiling in horror from an act of pollution. But, if it be not obvious that the spilt blood of a comrade cries for vengeance, the funeral—and we know that funeral ceremonies date back to Neanderthal times, say, twenty thousand years ago at least—is bound to excite a wrath proportionate to the sorrow. Seeing, too, how prominent a part is played by the loud-lamenting women on such occasions, we can understand all the better how the cry of the outraged mother's blood makes itself heard. It remains to be added that the savage has scarcely any idea of a natural death, being little acquainted with disease, which is proportionately mysterious when it comes, while on the other hand he is exceedingly liable to some sort of violent end.

It is not unreasonable of him, therefore, to generalize all such visitations alike as murder on the part of persons unknown; and the fact that the aggressors have escaped notice is got over by supposing that they must have achieved their fell purpose by means of an invisible magic. Thus in Australia one must always slay a stranger—it matters not who it may be, since collectively the outside world is guilty—if the grief and indignation exerted by a kinsman's death are to be allayed according to custom. How, then, if one is perpetually persecuting vendettas with the inter-marrying kins, is one to settle down with them to an amicable division of interest in the offspring of a given marriage? Thus, let us suppose that a father has been slain, whether own or collective, by an uncle, whether own or collective. On a patrilineal interpretation of his duty, the son takes up the feud, but on a matrilineal view of it he must stand on guard against reprisals. Just so, when two modern nations are at war, an international marriage does not constitute the children neutrals, but they are torn between conflicting duties.

If, however, a one-sided mother-right is replaced by a more or less equally one-sided father-right, a radical alteration is required in the laws of the blood; and, indeed their original meaning and sanction have gone, since all-one-blood can stand only by a very forced metaphor for anything but all-one-mother. All-one-name, however, is a possible substitute as a symbol of unity, a sort of war-cry. As soon, then, as the local group of men who make their wives cross over are ready to rally to some such common badge, they have a peg on which to hang the old obligations not to inter-marry, not to inter-destroy, and to slay the slayer from without. Such a name and badge will probably be a totem, which, involving the idea of some relationship with, as well as through, an animal-kind or plant-kind, would help to invest the bond of fellowship, which is now simply a local tie, with a mystic significance likely to enhance its binding and sanctioning force.

As for the origin of totemism, a vast and obscure subject, it will be enough to suggest here that it is not likely to have come into existence with the patrilineal kin, if this is later than the matrilineal, but more

probably goes back as far, or almost as far, as the parallel institution of exogamy. In that case, since the totem would be ultimately connected with a food-group that was conscious of its unity through the mother's blood, the association with animal or plant giving rise to the common name would presumably arise in one of two ways. Either it would have to do with their staple-food, so that for instance they would be known as the turtle-men if they ate turtles, and understood the mystery of hunting and humouring the turtles; or else it might rest on some notion that the mother's blood was stimulated into childbirth by what she ate, or possibly by what she did not care to eat, during the nervous months of pregnancy. Be these guesses sound or not, the almost world-wide distribution of totemic designations, with implicated beliefs at least generically similar, would argue for the great age of the institution; so that, if father-right is relatively late, it would have had the totem-name ready to hand. Moreover, this would already possess a sanctity peculiar to itself, such as could make a group of stay-at-home fathers appear one body, not exactly as a fatherhood—for they may have still been fathers without knowing it—but rather as a brotherhood, who, because they were all named after only animal or plant, were bound to enjoy one *mana* and to observe one set of taboos.

With this complete reversal of the point of view from which relationship is regarded under father-right, the mother's position changes for the worse. It is indeed sometimes thought that, however matrilineal and at the same time matrilocal a human group might be, it could never be matripotestal in the sense of woman-governed; the reason being that the muscle is all on the side of the male. Now even if this be granted—and, although less heavily built, the primitive virago may have been both tough and fierce—authority has its moral as well as its physical foundations. If the earliest law and religion centre round the sanctity of the mother's blood, she—that is to say, the plurality of mothers from which the group drew its life—must enjoy a standing, as a sort of queen-bee of the hive, that cannot but ensure her a certain dignity and even power. After all, under mother-right every male, in so far as he plays the husband, must experience for the time being a sort of inferiority-complex, as one who exists on sufferance among strangers; whereas the womankind have all the while the uplifting sense of being at home with their surroundings.

But now let the process be reversed, so that the woman must quit the home of her youth, not temporarily, as under matrilocal conditions the male is apt to do, but so that her lot is exile for life. As they phrase it in Indonesia, she must perform a "deer's jump." Her people will have taken what is usually known as the "bride-price" for her, though it is really the price of the children that she is going to bear for the benefit of the other group. Hence they are in honour bound to have nothing more to do with her; or at most may be on terms of distant politeness, addressing her as "you" instead of "thou." The last thing that they desire is to see her sent back to them, because this means that for sterility or some other cogent reason she has been divorced and disgraced; so that the marriage-price must be returned, unless a sister will be accepted as a substitute.

From her point of view, the transaction in which she seems to us to figure as a mere chattel handed over the counter is not so degrading as might appear on the face of it. She has cost something to acquire, and her husband and his people will value her accordingly, if she does her mothering amply and well. Her real trouble is that the female society into which she now enters is without cohesion, a mixed lot of wives assembled from various quarters, and hence more likely to be jealous of each other and quarrel than to combine to keep the males in order. Even though under the new system her relations with her husband are likely to be more close and permanent, yet so long as the sexes live and work more or less apart, as is usual in savage society, she loses more than she gains, by becoming an individual mother instead of what once amounted almost to a collective one. Group-affairs as such henceforth concern the males only, and a domestic policy in which the woman is consulted shrinks to the question of how her particular brood is to be reared and fed. She can have no part in the rites that concern the local god or totem ; for its *mana* is independent of her blood or that of any other mother, and requires a new theory that somehow gives the united fathers the credit of passing on the corporate life and luck. Religiously, and therefore legally and morally, the inferiority-complex passes to the woman.

Economically she may be no worse off, and she may taste the petty triumphs of a queen of the harem ; but the glory has departed. She is now little more than a counter in a game played by men. The days being long over when gathering was the mainstay of human existence and she could vie with the male as a food-getter, she was destined to become ever more parasitic on the man as greater demands were made on the strength and skill necessary for big-game hunting, herding, advanced agriculture that involved the use of traction-animals, and systematic predatory fighting. As for her sacred character, to which the mystery of child-birth formerly bore witness, such a notion always fluctuates in savage religion between the opposite poles of mystic potency and uncleanness ; so that the very source of her earlier influence might, under altered circumstances, prove an occasion for multiplying her disabilities. Half-priestess and half-witch as she had always seemed to the mere male, he had to regard her chiefly in the latter light now that she stood no longer for social strength but rather for individual weakness. Thus if the moral position of women were to be made the sole criterion of social evolution, it might lead to some queer results.

It has been necessary, even at the risk of some very speculative reconstruction of the earliest history of the species, to bring out the contrast between mother-right and father-right in their most uncompromising forms, in order to illustrate the effect of a strongly developed kinship system on the moral relations of husband and wife. Before one looks into the facts it is all too easy to imagine that the early home consists of father, mother, and baby, and that by the time they are grandparents a nice little society has grown up with the original progenitor in command. In reality, however, it would seem that the individualization of the family, as a partnership involving common bed and board, is the outcome of a slow and tortuous process of evolution. So long as marrying out did not imply living out, love in absence had no chance of prevailing against the

sympathy of close but non-conjugal cohabitation. The woman's part was in these circumstances to play the mother rather than the wife, and her real home was the women's camp where the women and younger children slept together apart from their elder sons and brothers; and the women's camp, thus hedged off from male interference, would doubtless act solidly, as well as shrilly, together in support of the feminine point of view. In the same way the men would be organized on a sort of regimental plan, according to which authority must be mostly a matter of seniority; so that between them the elder women and the elder men would take the lead as groups rather than as individuals. Moral relations would thus be felt less as inter-personal ties than as collective obligations. There would be plenty of loyalty but little love. The mutual attractions would be felt in and through concerted movements of a mobbish type, and sex and age between them would determine conduct almost regardless of private inclination or capacity. It remains, then, to review shortly the group-attitudes that resulted from a domestic life dominated by kin in the place of the individualized family.

First, then, as regards the relations between the sexes, enough has perhaps already been said to show that the intercourse between them, so far as they involved no conjugal familiarities, would tend to throw a glamour of mystery over the woman's side of life; such as would at once protect women from male bullying, and give them authority, more especially as peace-makers. For the rest, their relative importance as a sex would depend largely on two things—the value of their contribution to the food-supply, and the extent to which they managed to keep their marriage-arrangements in their own hands, so that they chose their lovers and were not assigned to them to suit their brothers' convenience.

Next, as to the relation between children and their elders—whereas the girls would form a permanent part of the women's camp and be duly brought up in its ways, the boys, as soon as it was advisable to separate them from their sisters, would go off to sleep and live with the men. There is no reason to think that here they would not be kindly treated. The relation between a youth and his maternal uncle is always marked by a friendliness that is conspicuously absent from his more formal attitude to his father, so long as there is any question of a divided authority. Indeed, it has been already noted that the terrorism which marks an Australian initiation is accounted for largely by the fact that it is practised on the novice by the inter-marrying group and not by his own kinsmen.

In any case the boys act and suffer as a class, and the fact that they are doing exactly what their elders did before them makes the educational machine run smoothly. The age-grades succeed each other like the waves of the sea; and at any time the strength of the group, reckoned in males, consists of three major categories—a promising crop of youngsters, a corps of trained hunters and warriors in their prime, and a body of elders sage in counsel and versed in luck-bringing ceremonies. All are equally necessary to one another, and the normal group is well aware of the fact. One must not make too much of the occasional cases of infanticide; or, at the other end of the scale, of senicide, namely, the putting away of the old and feeble. Travellers of the baser sort are fond of

adorning their pages with such horrors, but they accompany unusual conditions, namely, either a state of extreme privation, or one of degenerate slackness and irresponsibility. The typical savage takes the greatest pride in the fecundity of his womenfolk; and on the other hand is so amenable to the authority of his seniors that gerontocracy, the rule of the old, might fairly be said to be the earliest form of government. It must be remembered, too, that the living regularly believe themselves to be in the closest communion with their dead; so that the greybeard on his way to become an ancestor has all the more power to bless or curse credited to him, as it were, by anticipation.

To sum up about the kin or food-group conceived as the earliest type of social unit, it is not as my husband, my wife, my child, but as our men or women, young, middle-aged, or old, that one and all think of themselves in their most intimate relations with each other. To realize the collective personality appropriate to sex and age-grade is their only way of feeling, and being, at home. The moral law is summed up in the word "Imitate." The harness of custom will hold so long as every rank in the linked procession conforms to the movements of the rank in front. The philosophy of "follow one's nose" will suffice if fortified by an occasional growl from the older and stronger when the rear ranks break step or lag. A communistic system depends for its success on the average performance of the average man; and it was within the compass of the average intelligence to grasp that the primitive kin must not quarrel, more especially over its own women, and that it must share its takings in the way of food fairly and squarely. As for the male duty of protecting the breeding mothers, that must be done vicariously as long as a man ate at home but wived, and so all-unconsciously bred, abroad. So much, then, for moral life within the home—the circle of immediate symbiosis. Meanwhile, any kind of exogamy implies dealings with neighbours. What, then, of moral relations with them? On what minimum terms of mutual forbearance or positive amity can an inter-marrying union of social groups be established?

(b) *Tribal Virtues*

The tribe comes gradually into existence because to shake one's club at the foreign male, and to make eyes at the foreign female, prove in the long run to be incompatible proceedings. In proportion as marriage involves cohabitation between the parties, whether it is the husband or the wife that plays helpmate to the other group, two domestic circles must intersect. Nor can it fail to strike them sooner or later that, so far as they can act conjointly in consequence of this intermixture, they are twice as strong as against third parties. Before any such co-operation can occur, however, they must be able to converse in something better than the language of signs. Now we do actually hear of cases—one in point is that of the Carib invaders of the Lesser Antilles, who had killed off the Arawak males and appropriated their womenfolk—in which the wives speak one language and their husbands another. In such circumstances, however, there might well happen what both African history and Greek legend show to be humanly possible, namely, that the mothers should

bring up their sons to slay their own fathers in revenge. Normally, however, when the inter-marrying groups are on some sort of equality in power, not to mention culture and race, they are bound to come to terms about their matrimonial cross-connexions. On the matrilocal system, the barest toleration on the part of the woman's brethren towards her more or less furtive lover will induce the latter to protract his stay; and, once settled in the new camp, he will have to pay for his keep by making himself useful.

A patrilocal system, on the other hand, will always be somewhat more difficult to establish, since it means some hard bargaining, prefaced it may be by not a little poaching, before the women can be parted from the society of their mothers. Somehow, male dominance must have reached the point at which the united wishes—we had better say the united curses—of the mothers have ceased to exert much practical effect. As for the hardship of being cut off from one's own people, that must depend on the extent to which the economic life favours close association between the separate food-groups. Even in the richer kind of game-country hunters need a good deal of room; while fishing tends to concentrate round scattered spots on coast or river.

On the other hand, there will always occur seasons of plenty, or periods of interrupted labour during which the people live on their stored provisions wherever shelter is best obtained, when the scattered bands can assemble to hold high holiday together. We need to go back, however, to the etymology of the word "holiday" to appreciate the taste of the savage for collective ceremonies which stand with him for the highest value that life affords. Even food is not so important in his eyes as the mystic procedure whereby he seeks food and all other blessings at the hands of the unseen powers. For, however secondary its function when regarded as a means to living, his religious life has come to stand primarily and in itself for something more than living, namely good living. This common interest in sacred rites which gives all a sense of heightened being, in that it causes them to lift up their hearts together, is the chief source of such moral sympathy as gradually grows up between them. The firmest spiritual nexus of tribal life is a common worship.

That economics will follow in the footsteps of religion is easy to see. The so-called silent trade, when one party to the transaction nervously deposits his object of barter on a prominent stone, and retires into the bush until the other party has had time to remove it and substitute his *quid pro quo*, is a tiresome mode of commerce. On the other hand, a religious festival is at the same time a fair when, thanks to the prevailing "truce of God," folk otherwise none too friendly can indulge in the chaffering of the market without risk of coming to blows.

Again, law likewise waits on religion for its opportunity. The best way of settling a quarrel is, firstly, to get the disputants to meet and have it out, and, secondly, to bring this about in the presence of third parties, who have no interest in the matter one way or the other, and do not want to be disturbed by feuds such as always tend to spread. Thus in Australia a visiting group is expected to come out on its first arrival with everything unpleasant that it has to say about the conduct of its hosts, who are

equally outspoken in their recriminations; the men shout and brandish their weapons, the women intervene, and, after much steam has been blown off, all cheerfully assume their party-manners. Similarly, on occasions of tribal assembly more serious cases of trouble between kins and local groups are disposed of by some kind of regulated fight, such as tends to become more and more symbolic, a mere vent for angry feelings; as when the culprit is let off after he has stood up to a shower of spears or boomerangs, which he is usually quite competent to dodge.

All such association, then, under the stimulus and shelter of religion, clearly makes for peace; and, even in a loosely aggregated society of semi-independent groups, between which a certain amount of sneaking murder persists on the score of blood-revenge, causes them in the long run to extend the area of moral obligation from kin to tribe. The separate brotherhoods come to acknowledge a common cousinhood. Human society has reached the stage of the multi-cellular organism.

Now the savage doubtless always remains collectivist or group-conscious in his moral outlook; but at least he becomes aware, when the tribal spirit develops, of competing group-loyalties, of which the more intense has the disadvantage of being likewise the narrower. Common customs, then, and more especially, as we have seen, common religious customs, can do much to promote friendly relations. But something more than a diffused friendliness is required to bring home to the moral consciousness the subordination of kin to tribe as part to whole. Definite organization of a centralized type must be somehow evolved. In a word, group-regimentation implies an overhead rule.

Thus tribalism thrives on war. In North America we find the very word for tribe meaning those who fight together. War, however, has itself to develop from the loose skirmish to the serried order of battle, and the authority of the war-chief will vary accordingly. His best chance is to combine executive strength with religious prestige; and the two tend to go together, since success and *mana* are for the savage almost convertible terms. War in its turn leads to conquest, and at this point tribalism, which is essentially a system of co-ordinated groups, passes into State-organization or polity involving some sort of class system. At its crudest the conquerors form a governing caste, while the conquered are little better than slaves or serfs. Unless inter-marriage is prohibited, however, between the upper and lower orders, an aristocracy of status will gradually be replaced by one of merit. For the rest, the rule of the stronger will assume the cloak of a superior sanctity, and custom will confer a consecration on the established régime. Morally dubious, however, as such beginnings may seem to us, let it not be forgotten that our civilization is their ultimate outcome, and that we have in the course of the process become ever more conscious of common interests, and of a common duty to promote their realization.

(c) *Inter-tribal Virtues*

Whereas savagery scarcely extends beyond the limits of tribalism, while on the contrary it may barely attain them, it must not be supposed that at this level of society the foreigner is regarded as a pure enemy, a being

without moral rights of any kind. Undoubtedly, in the early world, it is the only sound policy to bristle up on the approach of the strange dog. But his very strangeness is a protection to him, investing him with *mana*, a power to bless and to curse. It is quite a chance which aspect of him will prevail. Either he will be slain offhand; or else he will be hospitably entreated, so that he is made free of board and, in the fullest sense, of bed as well. In Australia, for instance, a native will make long journeys into foreign parts, not without risk of sudden death it is true, but in the main safely, and on such terms that, as Lord Avebury puts it, he finds himself entitled to "a thousand miles of wives." When he turns up among a strange group, he will be closely questioned as to his identity, and must explain it in such totemic terms as the others can appreciate. Failing to do this, he will probably be speared; but as soon as he has made good his footing he is welcome, and, if he has a new corroboree tune or step to impart to them, so much the better. In this way customs spread, and common culture makes for common understanding. Indeed, inter-tribal marriages are fairly frequent, and the subsequent initiation ceremonies, when the education of the future husbands is entrusted to the group from which the wives are to come, gather the folk together on a scale that might be termed incipiently national.

It is a long way further, however, in the scale of social development when, as in North America, a group of fighting tribes find it convenient to frame a pact whereby the entire confederation, so long as it is unanimous, makes war or peace together. Commerce, again, breaks down the barriers between alien peoples, and the trading voyages of the Pacific region are peacemaking in their effects, so long as the navigators do not find piracy and head-hunting more satisfying to the adventurous spirit. Meanwhile, movements of population due to various causes, mainly economic, disturb the social balance, beginning in clashes but usually ending in some sort of amalgamation; so that the world grows ever more mixed alike in race and in culture. To this larger world the moral consciousness becomes slowly adapted; though, if we are to-day more humanitarian than the savage in theory, our practice may still leave something to be desired.

(2) *Activities making for Personality*

(*a*) *Virtues constituting Manliness*

It has already been pointed out that, just as there are no instincts that have not the good of the race for their ultimate biological purpose, so there are no virtues that are strictly self-regarding; since, in so far as they minister to our moral individuality, they are at the same time helping to make us more useful to our neighbours. On the other hand, even in the most communistic of primitive societies everyone must, as a matter of self-interest, mind his manners, lest he or she fall too conspicuously below the general standard of respectability; for that way lies suffering, with sudden death as its downward limit. Even if the kin-group is lenient towards its feebler folk, these must approve themselves fit before another group is likely to allow them to mate with any of its members. Thus, although moral competition does not take the form of striking out in new

directions, there need not be any corresponding lack of individual enterprise as regards excelling in all customary pursuits.

In a word, the ambition of every savage is to live up to the fashion. As has already been said, he is not without a desire for self-realization, but it is an exterior self that he has mainly in view. By a sort of imitation turned inwards he identifies himself with a copy of what the best people do, and then tries to copy this ideal copy as faithfully as he can. If he can in imagination see himself making a good show, he is satisfied. Let him on the other hand "lose face," and his self-respect is gone. He cannot stand up to an adverse public opinion. Nothing is so galling to him as ridicule, however ill-deserved. He must always be on his dignity, and nothing is easier than to offend him by demeaning him in the eyes of his fellows. Half his troubles with the white man are due to more or less unwitting breaches of etiquette on the part of the latter, whose most radical mistake is to forget that the savage is a gentleman, and as such decidedly nice on a point of ceremony or honour.

Given, however, a sympathetic audience, no one is more ready to play the man; while, within her more limited circle, the same applies to the woman. We have only to think of the fortitude displayed by the American brave under torture. As sheer drama it is superb. Ringed round with his enemies, he will force them to admire him; and, since their moral standards agree with his, he doubtless succeeds in doing so. Now a self-esteem so closely allied to self-display has obviously its petty as well as its nobler side. It may produce the coxcomb as readily as the hero; many a savage warrior, in truth, being an odd mixture of the two, while as for pain, his wounds received in battle may well have cost him less than those incidental to his toilette. On the whole, however, we may say that this anxiety to shine keeps the average individual up to the mark alike in the essentials and unessentials of current conduct, so long as the social system is intact; whereas, if the cross-imitations are interrupted, the morals break down.

For the rest, a responsiveness to the social drill being more passive and less voluntary than a true self-control, which involves assent to an intelligible principle, the repression entailed is greater. Hence savage morality is apt to present the contradiction of a rigorism tempered by orgy. Periodically custom allows the savage to let himself go, usually on some religious excuse, and for the time being he seems to part company with all his moral rules. The false notion that this in his normal condition, instead of an occasional remedy designed, as they say in Ashanti, "to make the heart cool," is responsible for many an undeserved libel on the general character of worthy folk, who despite such outbreaks are for the most part steady-going in the extreme, as the stability of their institutions proves. We must blame the custom rather than the individual, if, in order to do the correct thing, he must at stated intervals behave as though temporarily intoxicated or downright insane. The same person can, when occasion demands, throw himself with equal abandon into duties that tax his powers of self-sacrifice to the utmost, more especially if a certain magnificence of gesture, as for instance in the way of reckless courage or equally reckless liberality, is thereby achieved. Making allowance, then, for the ready-made cut of his moral garb, we can see that it is

a proper man who wears it. Under civilization each of us has a far better chance of securing a fit; but even so the happy mean between uniform and fancy dress is none too easily attained.

(*b*) *Virtues constituting Godliness*

It remains to consider the effects of primitive religion on the inner life so far as these make for an increase of moral individuality, that is, of the power to choose, initiate and direct in all that relates to the good life. Over and above such manliness as can be fostered in ordinary folk, there is needed the supermanliness of those rarer spirits whose function it is to lead the rest. In the eyes of the savage such men stand nearer to the gods, or actually rank as gods. Hence godliness is no bad word to express the superior degree of enlightenment and driving force manifested in those whose natural gifts, fortified by a suitable education, mark them out for positions of social authority, with a social responsibility thereto attaching in strict proportion. One must not, of course, exaggerate into a difference of kind what is but a difference in the degree of realizable capacity as between one man and another. Yet it is plain that, so long as biological deviations from the average occur, it must profit a human society to utilize those conducive to its more intelligent management.

At the same time, social sympathy would seem to rest chiefly on the recognition of an equality of need rather than on that of an inequality of merit. If a human group is to remain morally at one, it will not do to emphasize the dependence of one part on another, but on the contrary to make the most of the common dependence of each on the rest. It is bad alike for inferiors and superiors to regard themselves severally as such; but one and all can afford to translate the superiority implied in leadership into something relative to the general good, namely an opportunity and a call for fuller service. The " super " of the superman may thus be, as it were, detached from him and represented as a capital value which really belongs to all, though lent to him on trust. It would be a fatal policy to level down all talents to the minimum, or even the average, ratio of efficiency; but to level them up by recognizing a transcendent or divine standard, to which even the best men with all their efforts can but imperfectly attain, is bound to bring out all the power that a lofty aspiration can excite in human nature. Religion, together with morality and education, must always support a doctrine of aristocracy; yet it must do this in conjunction with a doctrine of humility that proclaims a sense of infinite shortcoming to be the secret of all striving after the ideal, and makes this divine discontent with self the final test of human nobility.

Now primitive godliness is, from a civilized point of view, a very doubtful type of virtue, and if its moral value is to be justified it will be necessary to examine it at some length. The manly savage, indeed, we have not great difficulty in understanding, even if he sometimes seems to us to go to the wolf for his model of what a man should be. But we are suspicious of the man-god. Indeed, none of his modern analogies, consecrated king or infallible pope, canonized saint or inspired poet, can be said to enjoy an authority that is divine beyond all dispute. On the other hand, when biology puts forward a theory—of course it does not pretend to be an ultimate explanation—of genius as a happy combination of

unusually potent genes,[1] it does nothing to show why, and in what forms, society ought to utilize and respect it. A moral philosophy, then, needs to think of outstanding human goodness in some way better suited to its own purposes. Hence, so far as the savage can be credited with a conscious doctrine on the subject, its main tenets may turn out to be less inadequate than might at first sight be supposed. For the belief in *mana* more or less explicitly involves two assumptions : firstly, that all good *mana* is a gift to a favoured few who must show themselves worthy of it ; secondly, that it is meant to be used for the benefit of all.

Thus, on the one hand, the possession of *mana* is held to be conditional on the observance of taboo. Wonder-working is incompatible with self-indulgence ; nay, to be truly great a man needs to cut himself off from the interests and pleasures of ordinary life—must " scorn delights and live laborious days." Not only is he bound to face the stern discipline incidental to initiation, but he needs to maintain his austerities throughout life, lest his indwelling power should depart and leave him an empty vessel. If he is to inspire others with a faith in his helpfulness, he must first possess faith in himself ; for the impotence of the charlatan is proportionate to his want of self-respect. At all levels of society, including that of savagery, there are hypocrites whose sanctity is but an official smugness which they sport like a mask ; yet these count for very little beside the genuine leaders, in whom a certain honesty of purpose must always prove the secret of their strength.

Again, on the other hand, good *mana* is known by its fruits. An anti-social wonder-working is rated as black magic, and plain men see to it that the sorcerer dies the death. No doubt the use of good *mana* includes a power to punish with curse or excommunication, but this is strictly limited by the public interest, being simply a way of calling down the justice of heaven upon the backslider who is at once criminal and sinner. Indeed, the principle of the responsibility of leaders is so well recognized in the primitive world as even to be overdone. That one by his own fault, such as neglect of his taboos, should be forcibly deprived of his position of authority, is reasonable ; but it is hardly so reasonable that sickness or old age should condemn the worthy ruler to an abrupt and violent end. Yet such a doom is often allotted by custom to the savage potentate who, in the heyday of his powers, has been accounted to sway the very universe, to make the sun to shine and the rain to fall, for the benefit of his subjects. One of the many paradoxes of human religion is the view that it is possible to propitiate and honour a god by slaying him in another of his aspects. The primitive king, moreover, takes up office with a full knowledge of the conditions under which he must lay it down, and is thus in a sense a willing victim—one who identifies his sacred mission with his very life, and is prepared to revitalize with his own blood that power of superhuman guidance which must never grow feebler if the community is to last. On the other hand, such a death is regarded by all concerned as a translation to a sphere of greater majesty conjoined with usefulness ; for the tomb of the departed monarch becomes a shrine, his relics are prolific in miracles, and his ghost is uplifted to rank among the gods as a source of blessing to all future generations of his people. Even so, such

[1] See the Article on *Biology and Human Progress*, p. 238.

public divinity is only to be purchased by private suffering. Indeed, a regime of custom, as compared with one in which the individual is more free to choose, possibly offers fewer opportunities of evading the fundamental law of society that greater privilege stands for harder service.

It would be an endless task to consider in detail the many types of leading men whose social position carries with it a more or less sacred character, with a corresponding obligation to behave in a strict and circumspect way. From a modern point of view, we might be tempted to classify them according to their functions as lay or religious, chief or doctor; whereas really one and all in their own eyes are wielding a power which, whether inherent in their office or derived from ceremonies, is something, as it were, superadded to their ordinary personality, a communication of energy from a source lying beyond the range of common experience and unexplainable in terms of common sense. It is not, of course, as if none but a great man had any chance of access to such a higher plane In the first place, all the public rites of the community have the same end in view, namely, that of tapping some sort of supernatural grace. In the next place, the meanest individual can expect his little share of *mana*—a slice of luck, a touch of inspiration. Yet, on the whole, it is reserved for the man of light and leading to play the part of intermediary between the people and their gods; and it is on such a theoretical basis that primitive government implicitly rests, being always in the broadest sense of the term a theocracy.

The anthropologist has to recognize that there are many possible ways of symbolizing the divine; but, however it is figured and explained, whether under an impersonal and quasi-material or under a personal and quasi-human form, it is universally believed to stand for all that human nature longs to enjoy more fully than it has yet—strength, wisdom, happiness, duration of days. At the same time the savage world at large is also conscious of something antithetic to the divine—another set of influences that conspire to encompass life with horrors and drag it down into death. Balancing uncertainly between these opposite stresses of supreme hope and supreme fear, the majority in times of peril turn to the few who can deal boldly with the critical situation. When the crowd panics, those in charge of the emergency exits must not lose their heads. In such circumstances the leader is called upon to show more confidence than perhaps he feels; and it is not only the bad doctor who tries to look wiser than he is. Hence it would be unfair to judge the man who is reputed to cast out disease-devils as a solemn humbug, because he sometimes seems to descend to conjuring tricks, as when an Australian medicine-man pretends to suck out magic crystals from the body of his patient. It is a professional gesture that is in strict keeping with the official tradition, and is adopted, without any sense of guile, as part of a treatment designed to carry conviction on the face of it. Indeed, in order to be popular all authority must somehow manage to be impressive; because simple folk believe mainly through their eyes. On the other hand, in order to appreciate the man who stands out among savages as of superior character and ability, we must endeavour to project ourselves into his inner life, so as to discover what kind of disposition it is that renders him so strong and efficient. Moreover, we may be sure that he

has not got what Plato would call " the lie in the soul," but on the contrary is upheld by a sense of being in touch with some higher reality. On its intellectual side this experience of *mana* is hard for us to interpret, because primitive theology is a mass of obscurities and contradictions. Morally, however, it likewise involves emotional conditions that we can appreciate better, since they reflect far more clearly than any play of ideas the common and abiding tendencies of human nature.

Rites may be divided roughly into negative and positive, according as their main purpose is either to keep away curses or to attract blessings. The evil avoided or the good sought is always of a mystic kind, that is to say, is held to transcend the ordinary alike in its causes and its effects. Hence, being such as to stir the mind to its very depths with transports of dread foreboding or else of exaltation, the experience in question tends to acquire more significance on its moral than on its material side; so that the fears and hopes of the religious man come to be largely concerned with accursedness and blessedness, more or less clearly conceived as states of the soul.

Thus, to deal first with the subject of negative rites or taboos, a typical way of representing their object is to think of it as the avoidance of uncleanness. It is a spiritual uncleanness that is meant, though savage religion—and advanced religion is ever liable to the same fallacy—is apt to fall back on the literal sense of its symbolic act, so that, for instance, a savage will indulge in an endless number of lustral baths, or scour his inside with purges and emetics, in order to get rid of the sin for which the very name that he commonly uses means " dirt." Another difficulty of rudimentary religion is to distinguish between a moral and a merely ritual purity. Many taboos would seem to have begun as almost irrational phobias[1]—for instance, the fear of contact with woman's blood. Thus it is but gradually that round such casual centres of primitive attention there gather all sorts of vitally important obligations; as, for example, the laws against incest and the murder of kindred may well have developed out of some such quasi-physical repulsion. Indeed, the path of the strict observer of tradition is beset with so many pitfalls, a devil lurking at the bottom of every one, that he may be excused if he is more immediately occupied with walking warily than with attending to the precise direction in which he is going.

Nevertheless, the mere act of restraining oneself from overstepping the bounds is not destitute of positive benefit. To practise chastity, for instance, may begin as a ritual precaution, but the self-control therefrom resulting is a spiritual asset, in that it promotes the sublimation of sexual desire[2] as well as otherwise assisting to discipline the character. The same growth of moral value can be noted in the case of fasting, or in that of the sacrifice of property. At first these are repressions of normal instinct induced by almost meaningless fears, causing good food to be treated as if it were poison, and useful objects to be thrown away as if they were infected with disease. Yet to endure such deprivations is good for the soul in the long run, not exactly for its own sake, but because it

[1] See the Article on *Psychology*, p. 345.

[2] For an account of the process of sublimation, see the Article on *Psycho-Analysis*, pp. 372 and 375.

affords preliminary practice in bringing the will to heel and using it as the ally of reason in the work of shepherding the passions. Hence, to be pure and to be strong in heart ultimately go together ; and thus not only negatively, but quasi-positively, his taboos afford the savage a lesson in godliness by exhibiting it as the moral opposite of all such spiritual dangers and temptations as are most damning, that is, deadly.

Turning to positive rites, we perceive their general import to be the securing of mystic blessings ; which in turn, as having the transcendent and infinite quality that belongs to the supernatural, come to be chiefly envisaged as an enlargement and uplifting of the spirit. Here, again, the savage tends to confuse the ritualistic with the moral effect, so that the rite itself seems as it were automatically to communicate the grace. Thus a primitive act of religion is, on a short-sighted view, easily mistaken for a sort of pseudo-scientific operation ; and the civilized observer contemptuously notes how the unpractical savage goes on cheerfully performing absurd experiments, the outcome of which is *nil*. It may strike a more penetrating mind, however, as a little remarkable that the world should have persisted through such long ages in taking all this trouble for nothing. It is true that men have always prayed to the gods for their daily bread and all other material kinds of prosperity ; but this is but part of a larger hope that embraces all good living ; which in turn really amounts to the inward experience that it is good to be thoroughly alive. Rites, duly carried out after a preparation conditioned by taboo, are found to yield *mana*. Having suppressed the flesh, the godly man finds that he has liberated the spirit. He has acquired a fresh self, and one with which it is more encouraging and altogether more satisfactory to dwell. Even aboriginal Australia can talk, like Dante, of a " new life," such as comes with and through the puberty rites, and is experienced in even fuller forms in the progressive initiations to which the adult is subject. If the primitive theologian be asked whence the *mana* comes, his answer is halting and mixed ; but he knows *that* it comes, while his ritualistic tradition also tells him how it is acquired. His religious experiments, it is true, may not always succeed ; for often he over-excites himself, and generates a sort of temporary madness. On the whole, however, the godliness of the savage may be reckoned the chief source of the morale that has slowly but surely raised humanity from the purely animal level to a civilized condition.

CONCLUSION

The anthropologist is a man of science, and is therefore not called upon to play the philosopher and interpret human history from the standpoint of the ideal—a precarious task, since the philosopher is a man like the rest of us, and has to construct his notion of the ideal and perfect out of elements which are tentatively selected from the actual and imperfect. Nevertheless, to consider ourselves in the light of what we may reasonably hope to become is our first and last duty as self-directing beings. Strictly subordinate to this end is, therefore, the function of a Science of Man which provides a preliminary statement as to where we are at present, and how we got there. Such a science, keeping clear as it tries to do of any theory of ultimate value, is not strictly qualified to affirm the reality

of human progress at all. After a fashion, however, and without prejudice to the final verdict of philosophy, it can do this by observing the results of Man's competition with the other related forms of life. Indeed, as far as knowledge of fact can take us, we are on firmer ground when we take stock of ourselves as evolved animals than as undeveloped angels. Thus, in a quantitative way, we can attest the increased dominance of our species by reference to the growth of population and the greater average duration of life. A qualitative criterion, however, could alone serve to justify the philosopher in claiming, as against the dismal assumption of cosmic indifference, that this long historical process stands for the gradual unfolding of an immanent good. He must be able to show that through the ages mankind has advanced from a less to a more satisfying kind of experience—that the meaning of life has been somehow enriched. Can any such conclusion, then, be gathered from the foregoing account of savage morality? What, perhaps, comes out most clearly from such a bare sketch of the main facts, is the preoccupation of the primitive mind with brave dreams that, however fantastic in themselves, react on it to stimulate desire and to enlarge hope. As far back as we can trace him, Man appears as a visionary who has lived on an overdraft and traded on credit. Since, therefore, something infinite attaching to his notion of good has hitherto helped him on his way, it might well seem sound policy on his part to continue steadfastly to imagine the divine, and to treat it as the only true measure of the human.

THE CHARACTERISTICS AND DISTRIBUTION OF THE HUMAN RACE: AN INTRODUCTION TO ETHNOLOGY

By

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SYNOPSIS

Time and Space. Early forms of man, their antiquity and distribution ; the " missing link " — Criteria of race ; blood groups — Temperament and character.

Races of Man. The six great divisions of mankind, their distribution and physical characters.

Europe. Antiquity of man in Europe — Mediterranean, Alpine, and Nordic races ; their contrasting temperaments — The Turki peoples of Europe — The Basques.

Asia. Early man in Asia — Ethnic confusion in the Near East — The Eastern Turki peoples — Medes and Persians — Arabia, the home of the Semites — Palæo- and Neo-Siberians, reindeer pastoralists of the Tundra and Tayga — The Japanese ; importance of Ainu influence — China ; early civilisations ; contrast between northern and southern Chinese — The Moslems and Jews of China — Tibet — Mongols and Manchu — French Indo-China ; the " southern aborigines " — Malays — India ; Pre-Dravidian jungle tribes ; Risley's classification ; the caste system.

Africa. Main ethnic divisions — Hamites, Negroes and Bushmen — The pre-dynastic Egyptians and their modern representatives — The Arab invasions — Antiquity of the Negro in Africa — The true Negro ; the Negro-Hamitic peoples and their chief divisions, half-Hamites, Nilotes and Bantu — Negrito and Bushman — Hottentots — Indonesian influence in Madagascar.

America. Physical characters of population ; similarity of type, pointing to original common Asiatic parentage — Linguistic considerations — Culture of early immigrants — Food areas and cultural groupings — The Eskimo — Ancient civilisations of Maya and Aztec — The Chibcha and Inca — Savage tribes of South America.

Oceania. Australia and the island groups of the Pacific — Australoid fossil skulls in Java and Queensland — Migrations of Polynesians from Indonesia to the Eastern Pacific — Physical characters of Polynesians and Melanesians — Micronesia,

THE CHARACTERISTICS AND DISTRIBUTION OF THE HUMAN RACE: AN INTRODUCTION TO ETHNOLOGY

INTRODUCTION

Time and Space

In this Article we shall limit ourselves to the existing species of man, *Homo sapiens*, to which all the living races of mankind are conventionally referred. Moreover we shall consider only those forms of man that exist at the present time or have existed in the recent (holocene) period in which we live, and even here we shall confine ourselves to living peoples, referring only occasionally to the neolithic period and ignoring the earlier representatives of *Homo sapiens*—men of the Aurignacian, Solutrean and Magdalenian periods, *i.e.* of the latter half of the Old Stone Age—as well as their epipalæolithic (mesolithic) successors, transitional to the New Stone Age.

Yet, in order to have a background for our living races, it is necessary to make mention, however bare, of the older species of mankind which furnish the most important fossils of the palæolithic age. Fig. 1 (after Elliot Smith) represents the relative position of the more important species and genera of extinct man in relation to the races of the present day. It will be noted that none of these early men stand in the direct line of ascent of modern man; we have in fact to give up the traditional idea of the "missing link." There is indeed no single missing link joining us to the apes, but innumerable forms bringing us nearer as we go back in time to the common anthropoid ancestor. "In our first youthful burst of Darwinianism we pictured our evolution as a simple procession of forms leading from ape to man. Each age, as it passed, transformed the men of the time one stage nearer to us—one more distant from the ape. The true picture is very different. We have to conceive an ancient world in which the family of mankind was broken up into narrow groups or genera, each genus again divided into a number of species—much as we see in the monkey or ape world of to-day. Then out of that great welter of forms one species became the dominant form, and ultimately the sole surviving one—the species represented by the modern races of mankind."[1]

It is perhaps worth noting that of the older forms Piltdown man (*Eoanthropus Dawsoni*) is a relatively large-brained type with a lower jaw resembling that of a chimpanzee—in fact the jaw was at first held by many to be that of a chimpanzee accidentally associated with fragments of a human cranium—while the recently discovered remains of Peking man (*Sinanthropus pekingensis*) is of the low heavy-skulled type, with a great bar of bone running across the forehead above the orbits, but with

[1] A. Keith: *The Antiquity of Man* (1915).

a jaw clearly related in form to that of Piltdown man. Nothing is gained by endeavouring to estimate the duration of the palæolithic in terms of years, but we may agree that the trend of modern research is to place its end in Europe some eight or ten thousand years ago, while the imagination best deals with its earlier phases in terms of changes of geography, fauna and flora; thus England, Ireland, and the continent were one, there was no English Channel, and a greater Rhine, with the Thames

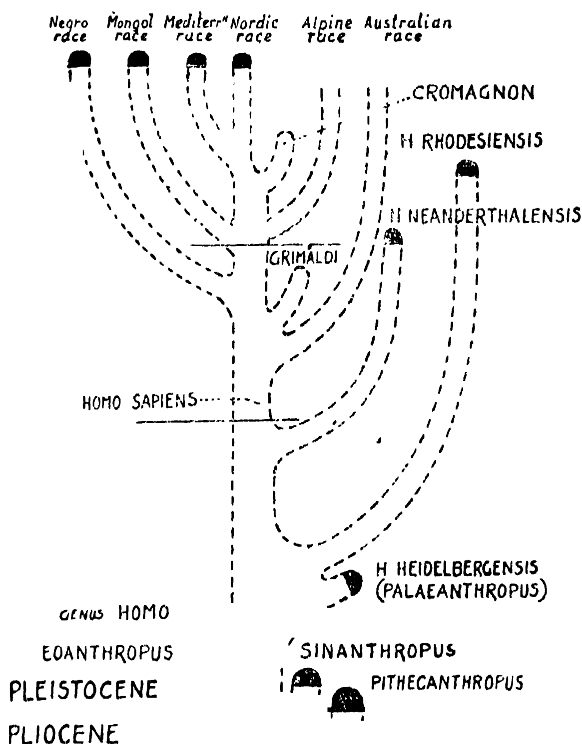


Fig. 1.—SCHEME SHOWING POSSIBLE RELATIONSHIP OF VARIOUS FORMS OF MAN

as affluent, opened into the Arctic Ocean somewhere to the south of the Faroe Islands.

Regarding the place of origin of man, we can only say that "somewhere in Asia" is regarded as the most probable; while as to the causes of differentiation of the main races of mankind, the only suggestion having even *prima facie* plausibility is that put forward by Keith, who regards the outstanding racial differences as directly due to qualitative and quantitative variations in the secretions of such glands of internal secretion as the thyroid, pituitary, etc. How far this fascinating hypothesis is true only the future can show.

Considering area in relation to time, *i.e.* the filling up of the world, if we accept Asia (whether East-Central or South-Western) as the cradle of mankind, it is worth noting that such early forms as Heidelberg and Piltdown man had reached Western Europe at the Chellean period—the dawn of the pleistocene, the recent or quaternary period of the geologists —while there is steadily accumulating evidence in the West of man's handiwork at an even earlier period, though no actual remains of tertiary man have yet been found. At the other extreme of the time scale, no substantiated trace of palæolithic man has yet been found in the New World, indeed all the evidence goes to prove that both North and South America have been peopled exclusively by our own race of man, *Homo sapiens*.

Here it is convenient to define two terms which we shall have occasion to use, *viz*. palæanthropic and neanthropic. The former is applied to all forms of man other than our own, the latter includes the many stocks of our species. In time, palæanthropic man as we know him at the moment is mainly of the Lower and Middle Palæolithic, but the discovery of Rhodesian man, an archaic form which persisted until a few thousand years ago, indicates how rapidly our knowledge may change. Neanthropic man appears in Europe with the Aurignacian period, *i.e.* at the beginning of the Upper Palæolithic.

The Basis of Classification

In attempting to define the term " race " we cannot do better than follow Haddon, who uses it to connote " a group of people who have certain well-marked features in common,"[1] with the addition that the group should be as large as possible, *e.g.* we do not speak of a Swedish race, although typically the Swedes as a group have certain well-marked physical characters, but we regard them as one of the chief constituent peoples of that much larger group having these same characters, which we call the Nordic race. While the number of characters that are to be taken into account is largely a matter of individual opinion—in the past there have been many systems of classification proposed—it is generally agreed that character of hair, skin, colour, stature, shape of head, shape of face and shape of nose, are among the outstanding criteria of race, with quality of hair as perhaps the most important, and it is these that we shall use in this Article.

These criteria are in the main empirical, only doubtfully to be related with environmental conditions. Thus, although it is true that the Negro race is confined to the tropics, and that in India skin colour is predominantly dark, it cannot be said that all or nearly all inhabitants of the torrid zone are dark skinned, witness Arabs and millions of southern Chinese, nor can more than a tentative case be made out for the association of a high nasal index with tropical conditions.

We may add that, apart from inter-breeding, the common criteria of

race are of extreme stability, and that if there ever was a time of considerable "plasticity" this is long past.

The criteria most generally useful are as follows :—

Hair:—This is generally recognised as of three qualities, *i.e.* "straight," "smooth, wavy or curly," and "woolly."

Colour:—Skin colour is more important than hair and eye colour, though dark skin and dark hair commonly go together while the correlation of hair and eye colour is by no means so close, *e.g.* in Cornwall and also in Brittany there is a dark-complexioned dark-haired light-eyed type of great physical attractiveness. As already stated, dark-skinned peoples are generally found in or near the tropics. On the other hand, there are a number of peoples living in the torrid zone who are true "Caucasians," belonging to the Mediterranean race, and such peoples (apart from sunburn and dirt) usually have relatively light-coloured skins, though these (wheat coloured to light brown, with perhaps a tinge of copper) are considerably darker than those of Europeans. The Hamites, especially the southern Beja (p. 467) of the Red Sea Province of the Anglo-Egyptian Sudan, are a good example of such "dark" or Allophyllian Whites, as they have been called.

Stature:—Here it is well to be precise : following Haddon, the terms "short," "tall," etc., will be used, wherever measurements are available, in accordance with the following table, stature being given in inches.

Pygmy ..	.. –58¼ in.	(–1.48 m.)
Short ..	.. 58¼–62¼ in.	(1.48 m.–1.58 m.)
Medium ..	.. 62¼–66 in.	(1.58 m.–1.68 m.)
Tall ..	.. 66–67¾ in.	(1.68 m.–1.72 m.)
Very tall ..	.. 67¾ in. +	(1.72 m. +)

That there is a considerable range of stature in most peoples is obvious, but here, as in other measurements, averages of groups of thirty or forty individuals come remarkably true ; moreover a tall race will not (apart from dwarfs) contain very short individuals nor a pygmy race tall men.

Head-shape:—Looked at from the side some heads will be seen to be long, others short (the hair must be discounted), while seen from above such heads look long and (more or less) round respectively. The various degrees of this distinction in shape are expressed by the Cephalic Index (living) or Cranial Index (skull), which is the ratio (or percentage) of the breadth of the head or skull to the length, the latter being taken as 100, *i.e.* $\text{C.I.} = \frac{\text{B} \times 100}{\text{L}}$. Except in artificially deformed heads it is uncommon for this figure not to fall between 65 and 90, and the vast majority fall between 70 and 85. The terminology commonly applied to this index (skull) is :

–75, long or dolichocephalic.
75–80, mesaticephalic.
80 +, round, or brachycephalic.

The difference of the index taken on the living and on the skull is about two units, hence the cephalic index can be converted into the cranial index by the subtraction of 2, and vice versa.

Character of face, prognathism:—Though a number of indices are in common use for the face, it does not seem necessary to discuss them in this Article. We are so accustomed to looking at faces that the terms "broad-faced," "long-faced," are self-explanatory, while all must have noted the varying projection of the forehead and cheek-bones (malar bones). Projection of the lower part of the face, especially of the lower jaw (prognathism), is common in Africa, and where it is extreme there may be definite "snoutiness." This is generally, and no doubt correctly, regarded as a "low" character, its opposite, "orthognathism," especially when allied with a prominent forehead, being considered "high" from the intellectual standpoint. But it should be noted that many Negroes have bulbous foreheads without being particularly intellectual, while the least developed races, with infantilistic crania, such as the Bushmen, may be relatively orthognathous.

Nose:—The nose may be long or short, broad or narrow, with its bridge flat, medium, or projecting. The relation of length to breadth is so important that it seems well to give the terms and figures commonly employed, and since there is no morphological identity of the nasal indices taken on the living and the skull, and no easy mode of conversion of one to the other, only the figures for the living are given. The index is again $\frac{B \times 100}{L}$, and the terms applied are :—

55–70 leptorrhine.
71–85 mesorrhine.
86–100 platyrrhine.

Noses that are broader than they are long (hyperplatyrrhine) are not very uncommon among Negroes. This index has proved of special use in areas in which the population is of mixed origin, *e.g.* in India it has been claimed that nasal index is an adequate guide to social status. The development of the root of the nose is important (low, medium, high), as well as certain forms of the nose. Here most of the terms are self-explanatory, but it should be noted that the so-called "Jewish" nose, though often called "Semitic," is not truly so, since the purest Semites have it not; it is characteristic of the ancient Hittites and their modern representatives the Armenians; it should be called "Armenoid," and where present in a typical form may fairly be taken to indicate the admixture of Armenoid blood.[1]

I[illegible] it be thought that undue space has been devoted to very commonplac[illegible]finitions, it may be stated that experience extending over many years [illegible] shown the absolute necessity, when writing for lay readers, to be ext[illegible]ely precise in definition if they are to grasp without innumerable ph[illegible]graphs the significance of physical characters. Moreover, distribut[illegible] maps of the various physical characters—stature, cephalic index, etc. [illegible]uch as those given by Ripley[2]—should be studied whenever possible (*se*[illegible]*g.* 2).



Fig. 2.—EUROPE: MAP OF CEPHALIC INDEX (MODIFIED FROM RIPLEY)

So much interest attaches to "blood groups," and such high hopes were at one time entertained as to the assistance they would prove to the anthropologist, that it seems advisable to devote some little space to them, though in the present state of our knowledge their importance is sensibly less than was at first hoped.

It was discovered in 1900 that there were definite substances in the serum of some bloods that would agglutinate, or clump, the cells of certain other bloods, and it was further shown that on this basis blood can be classified into four groups.[1] These groups are commonly represented by the Roman figures I, II, III, IV (sometimes by O, A, B, A B, with reference to the bodies theoretically causing agglutination) and the chief

anthropological interest of the blood groups lies in the varying percentages of each group in different peoples, for it was soon found that different populations—we dare not as yet say races, except in a restricted sense—were characterised by different frequencies of the four groups. Everywhere we find both II and III, but the proportion varies : *e.g.* to take large units, II is high in Caucasians, relatively low in Asiatics and Negroes, while III, comparatively high in the two last groups, is low in Europeans. Thus, in a general way, it may be said that while II is high in Western Europe this group falls in frequency towards the south and east, while III rises. But, with the exception to be noted immediately, it does not appear that the differences are sufficiently clear cut to enable the human varieties to be differentiated by blood tests. These tests, then, fail to justify the more extreme hopes entertained in the early years of their discovery ; rather must they take their place among the older and better-known criteria. Nor is this to be wondered at when it is remembered that groups II, III, and IV have already been found in the few orang-utan tested, while I and II have been found in the chimpanzee, for it is obvious that these facts indicate the high antiquity of the groups, unless indeed it be claimed that, unlike other anatomical traits common to apes and men, they are not part of a common heritage, but arose independently by parallel development.

There are, however, certain facts of great anthropological interest in the distribution of group I to which allusion must be made. To put it briefly, this group is found in an unusually high percentage of individuals of certain peoples occupying areas which are in a sense " outliers," so that it has been suggested that its presence in high frequency may be looked upon as an indication of the degree of isolation of the peoples in whom it occurs. A group of North American Indians (483), believed to be pure-blooded, give 91.3 per cent. of I, a percentage so high as to lead to the conjecture that before the Discovery the percentage of I may have been 100, while, as pointed out (p. 475), the variation in type in the inhabitants of America (other than arrivals in the last 500 years) has necessarily required a relatively lengthy period to come about. But against this must be set the Australians (1176), with a percentage of I of 52.6. This is only moderately high, and not so high as might be expected for the Australians on the isolation hypothesis. For it is a fact that the Australian must be regarded—for reasons that cannot be given here—as a more primitive and isolated member of *Homo sapiens* than the American Indian, while again the Australians show nothing like the degree of variation found in the latter. Actually the Melanesians of New Guinea (certainly with an element of Polynesian blood) and the Negroes of West Africa have about the same percentage of members of group I as the Australians. Moreover, one observer's figures give 45.5 and 54.5 of I and II for Central (Arunta, etc.) Australians, leading him to regard their blood grouping as ultra-European.

Population	Number	Groups I	II	III	IV
Americans	5,000	44.4	36.0	14.2	5.1
Germans (Schleswig-Holstein)	3,156	40.7	41.3	12.5	5.3
Russians (Moscow)	2,200	32.0	38.5	23.0	6.5
Chinese	1,000	30.0	25.0	35.0	10.0
Hindus (India)	228	31.8	18.5	40.9	8.7
Gypsies (Hungary)	385	34.2	21.1	38.9	5.8
Australian natives	1,176	52.6	36.9	8.5	2 0
Melanesians (New Guinea) ..	753	53.7	26.8	16.3	3.2
Negroes (W. Africa)	325	52.3	21.5	23.0	3.2
Indians (N. America)	1,104	79.1	16.4	3.4	0.9

The similarity of the blood of Hungarian Gypsies to that of Hindus, amounting to practical identity, will be noted, though the former left their Indian homeland hundreds of years ago.

We may add, as facts of the greatest interest though only indirectly concerning the subject of this Article, that: (1) Although, as might be expected, a new-born child, in whose vessels its mother's blood has been circulating, is of the same blood group as its mother, its own blood group —determined by heredity—asserts itself after a few months, and this is not necessarily the blood group of its mother, indeed it often is not. (2) The inheritance of the blood groups is on Mendelian lines,[1] though there is some disagreement as to the exact formula.

It is important to distinguish between race, nation, and people. As already stated, race is defined by anatomical characters, but it must be emphasised that the living races of the anthropologist are not regarded as corresponding to the species of the zoologist, but rather to smaller groups, varieties or possibly sub-species. Moreover, apart from anatomical peculiarities, races may exhibit physiological peculiarities in matters to temperament, *e.g.* it seems agreed that Negroes are more musical than whites. " Nationality " stands apart from race and is in the main a matter of history and politics, indeed most nations are composed of more than one race, *e.g.* the British nation is mainly a mixture of Nordic and Mediterranean races. The term " people " is generally used in a rather indeterminate sense, usually fairly obvious and often connoting a group that is neither racial nor national but united by some other lien, as for instance language, or some other particular form of culture. Tribe is commonly applied to a unit of the lower cultures, whose members have a common tongue, and, like those of a nation, usually act together in external affairs.

Language, which has been more studied than any other single human activity, is of such vast practical and political importance that it is sometimes hard to remember that this is but a special form of culture, no more a criterion of race or of primary assistance in classifying peoples than any other cultural feature. But because of the large part that language has played in our lives and cultures, as well as on account of ancient habit, we do habitually transfer linguistic terms to racial units, and only use

[1] For a full discussion of the Mendelian Theory, see the Article on *Sex*, p. 261.

dictates whether this is " good " or " bad " anthropology. Thus we speak of Semites, though " Semitic " is essentially a linguistic term, and this usage is sanctioned by anthropology, while to speak of Aryans in a racial sense is not generally considered permissible, perhaps because of the enormous area peopled by the most divergent races over which Aryan tongues are spoken. Nevertheless, similarities and differences in language are so striking, often go back so far, and are of such deep significance, that everywhere in the less well-known parts of the world classification tends to be largely linguistic, as for instance in Africa, where the distribution of the great families of language (see map) in a broad sense corresponds almost everywhere with ethnic reality, so that in general outline ethnic and linguistic maps of Africa—except in the north—would agree if superposed.

Although the study of temperament is only beginning, it seems necessary to say something about this, for if temperament be regarded from the racial aspect it will be seen as an important expression of racial mental quality. We will therefore deal briefly, on the appropriate pages, with the races of Europe and two highly civilised peoples of the Far East, the Chinese and Japanese. There are, however, certain pitfalls that must be borne in mind and allowed for. Social position—class—is perhaps as important as race; again, time, in the sense of the period of a civilisation, counts for much, *e.g.* to call the members of the oldest of Eastern civilisations " cruel " because torture and horrible modes of death were sometimes resorted to in recent times, with the implication that the white races are not cruel, seems little to the point in the members of a nation which two or three centuries ago used to " hang, draw, and quarter " its political enemies, while it is certain that no nation or people could have taught the Inquisition anything in the way of torture.

THE RACES OF MAN

The earlier attempts at the classification of mankind into a small number of great racial divisions are of historic interest only, nor is this the place to discuss the relative merits of the more modern plans, none of which are ideal. In practice the following scheme, with six races, and four or six great divisions of mankind, according as to whether we retain the term Caucasian as a synonym for the " white " man, probably works as well as any :—

The Nordic Race The Alpine Race The Mediterranean Race	Together comprising White or, to use a conventional but extremely convenient term, Caucasian Man [1]
The Mongol Race	Yellow Man
The Negro Race	
The Australian Race	

This is the scheme we shall adopt, though pointing out some of the more obvious difficulties, or at least infelicities, of nomenclature.

[1] Two other " races," the Dinaric (p. 441) and the East Baltic, are sometimes recognised, but are probably best regarded as of mixed origin.

No sooner is the Alpine race constituted than its western members immediately fall into two great sub-groups : the European Alpine round-head, with a cranium that suggests part of a sphere, and the Armenoid of Asia Minor, with the back of his head (occiput) flattened, great basi-vertical height, and in the living a nose so definite in shape that it is given a special name, " Armenoid." As to the so-called Dinaric race inhabiting the head of the Adriatic and neighbouring lands, if it is not a race of equal value with the other three European races—as some anthropologists consider it to be—it must be regarded as a greatly modified variety of Alpine, or as a cross between Alpine and Nordic with perhaps a touch of the Armenoid. Again, in Central Asia and the Far East, there are two groups which are both certainly Caucasian and perhaps both Alpine. These are the Turki and the Ainu. The former have a yellowish-white complexion, abundant hair, and a tendency to obesity—a quality apparently running right through the Alpine race—very high brachycephalic head, straight and prominent nose and dark but non-Mongolian eyes. The Ainu of Japan and the neighbouring islands, with their mesaticephalic heads, hairy bodies, and rosy complexion, can only be regarded as of the white race, wherein, unless we call them proto-Caucasian and speculate no further —perhaps the wisest course—we may agree that they belong to the Alpine race.

The Mediterranean race includes not only such obviously related strains as the Hamite and the Arab, but is enlarged by some authorities to embrace the Dravidians of Southern India and Ceylon, with aberrant types of their own as extreme as the Todas, distribution going far beyond that admitted by Sergi, whose work, *The Mediterranean Race* (1901), is the *locus classicus* for the use of the term.[1]

Having pointed out these difficulties, we shall first describe the distribution and physical characters—the latter very briefly—of the six races of man, and then pass on to describe the chief peoples of each of the great geographical units of the world—Europe, Asia, Africa, America, and Oceania.

White or Caucasian Man

The Nordic race includes such North Europeans as the Scandinavians, Flemings, Dutch, many North Germans, and some Russians. Many English and Scotch—particularly the allegedly " typical," *i.e.* aristocratic type of Englishman—must also be included, though the basis of the older population of the British Isles was Mediterranean.

The Alpine race includes European Alpine and Asiatic Armenoid branches. To the European Alpines belong the Swiss, South Germans, Slavs, French, and North Italians. This branch extends into Asia, and to it must be reckoned the Persian Tajik and the mountaineers of the Pamirs, among whom a type prevails which tallies almost exactly with

[1] In 1911 Elliot Smith suggested the term " brown race " for the peoples of proto-Egyptian type, *i.e.* the Mediterraneans of Sergi, and for a number of people, or an element in the population, of lands outside Sergi's area—the inhabitants of Southern Persia, Mesopotamia, some coastal parts of Asia Minor and the Nesiots of Malaysia (*The Ancient Egyptians*, 1923).

the Swiss representatives of the Alpine race. The West Asiatic branch, *i.e.* the Armenoids, is represented in antiquity by the Hittites (or one of the stocks entering into their nation), whose gods are pictured with the exaggerated Armenoid nose of the comic-opera Jew. At the present day the Armenoids are found in Armenia, the Levant, Mesopotamia, and Southern Arabia, and have given their characteristic nose to many Jews and Arabs. Of the Turki we have already said something on p. 441.

As already stated, it is doubtful whether there is a Dinaric race; if there is it must be included here.

The Mediterranean race includes the inhabitants of the Mediterranean peninsulas and islands—when these have not been overlaid by Alpines (Greece and much of North Italy)—of parts of Arabia (Semites) and of Africa north of the Sahara, where as Berbers they constitute the Northern Hamites or Libyans, even crossing the Sahara (Tuareg, and such tribes as the Cow-Fulani, *i.e.* those who have not absorbed much Negro blood) and so impinging on the Negro. All these may perhaps best be regarded as constituting a Northern branch of the Hamites. The Southern or Eastern branch includes Egyptians, Beja, Berberines, Abyssinians (with infusion of black blood), Somali, and Galla. It will be remembered (p. 435) that many of the peoples of this branch, even when free of Negro blood, are so dark complexioned that the layman, forgetting the quality of their features and the form of their hair, scarcely recognises them as Caucasians.

Passing eastwards, there are such less typical, indeed doubtful, " Mediterraneans " as the Tamils of India and related peoples.

Many Semites (Arabs and Jews) carry much Armenoid blood, a strain thought to have come in during the first millennium B.C. Apart from this, Hamites and Semites exhibit many physical and cultural features in common (including linguistic affinities), indeed there is good evidence for the existence of a former Hamito-Semitic culture.

The Mongol, or Yellow Man

The Mongol race, with many areas of interpenetration and contact metamorphosis, spreads westwards across Asia from the Pacific Ocean, nor is it possible to state its western boundary with any precision on account of frequent mixture and often confusion with stocks of Turki origin. It is however true to say that the great mass of the Yellow race lies east of longitude 80°. We have no certain knowledge of its area of characterisation, but considering the predominance of the Yellow race in Eastern Asia—with its great mountain ranges and former ice barriers of the Glacial Epoch—we may believe that its cradle-land lay in the area that we now call the Far East, south of 40° (the latitude of Peking), perhaps in the fertile plains between the Yellow River and the Yangtze-kiang.

" Wherever the race acquired its distinctive features, it wandered far and wide as soon as climatic conditions permitted, north into Mongolia, Manchuria and Eastern Siberia; west into Turkestan and Tibet; and south into Yunnan and Burma, and into what we now call Indo-China,

the Malay Peninsula, and the Malay Archipelago. Different groups had assumed distinctive characters, so that Northern, Southern, and Maritime Mongols became differentiated; and as the first and third of these subdivisions intermingled freely with other races, their differences from the Southern Mongols (who exhibit the characteristic features of the race in their extreme form) became further emphasised. To interpret the physical characters of the people we have to picture members of the Mongolian group wandering away from the centre (where the most intensive specialisation of racial characters was taking place) before the process of differentiations was far advanced, for on the fringe of the Mongolian domain one finds members of the race differing less emphatically from other human beings than, say, the Chinese do. But as this fringe extended its wanderings, it came at length into contact with the expanding edges of other races, in particular the Alpine people in Central Asia, and the Indian and Indonesian people . . . in the south."[1]

The physical characters of the Mongols are particularly well defined. The skin is some tint of yellow or yellowish brown; eye brown, generally dark brown; the hair is coarse, straight (almost circular in section), and generally sparse, noticeably so on the face; the head is generally round (but in some groups mesaticephalic); the cheek-bones are broad, and so prominent that, taken with the characteristic absence of depression between nasal root and forehead and the slight development of the brow-ridges, the whole face tends to have a peculiar flatness, which is as characteristic and much more general than the very distinctive "Mongolian" eye. Where the "Mongolian" quality is well developed, the inner part of the upper eyelid is continued over the inner angle (inner canthus) of the eye, the skin fold so produced extending to and fusing with the skin at the side of the nose; it is this, with the narrow aperture between the upper and lower lids, so common in Mongols, that gives the proverbial narrow oblique appearance to the Mongol eye, the orbits themselves and their position in the skull not differing significantly from those of other races. Stature is usually short (about 64 in.), but the northern Chinese are often tall (70 in. or even more).

The Yellow race is usually divided into Southern, Northern, and Oceanic Mongols.

The Southern Mongols, who in recent literature are tending more and more to be called Pareoean, have a geographical distribution that includes Tibet, the southern slopes of the Himalaya, China and Indo-China to as far south as the isthmus of Kra. In general they conform to the Mongol physical type, but are perhaps rather shorter (this does not hold for Northern China) with an average height of about 63 in. Many Southern Mongols carry a considerable strain of foreign blood, *e.g.* the more civilised Tibetans (Bod-pa) are described as betraying a considerable admixture with Hindu elements, while the peasant folk of the bleak uplands (Dru-pa) have clear brown or even hazel eyes, and among their younger women rosy cheeks are quite common. In China too there are wide divergences from the type; thus in Northern China skulls are mesaticephalic (C.I. 77) rather than round, and, as already stated, stature is high.

The great mass of Northern Mongols occupy Siberia, stretching from Japan to Lapland and coming south (roughly) to the Great Wall and Northern Tibet. Beyond this, west and south, there is a strong Mongol strain in many Turki and Finnish groups. Taking the Tungus as fairly representing the Northern Mongols, the highly brachycephalic skull of these and similar peoples gives place to mesaticephaly in some of the mixed groups, including even Siberian tribes such as Ostyak and Vogul (C.I. 77), while the Koreans, often with hazel eyes, have an aristocracy relatively tall and slim with long narrow noses. How this foreign strain reached Korea is unknown; in Japan we may fairly attribute the rosy skin, which is by no means uncommon, to Ainu admixture, though this will not explain the long and narrow noses of the aristocratic type.

The Oceanic Mongols range over Indonesia (including the Philippines), Formosa, the Nicobars (much modified), and Madagascar. These are the shortest of the Mongols, the stature in some groups scarcely exceeding 60 in., and include the darkest skinned members of the race (some Malays). The hair is as among other Mongols; the skin colour varies from a faint tawny yellow to reddish brown; the skull is brachycephalic (sometimes mesaticephalic); eyes black, often with Mongol fold; nose often small, with rather wide nostrils.

There is an undoubted connection both physical and cultural between certain island groups of Oceanic Mongols and some hill tribes of Assam. In the latter there is a very great variety in physical, especially facial, type, while in Borneo we can easily differentiate brachycephalic and mesati- or dolichocephalic types, some of whom show *inter se* a considerable degree of facial variability. This variability of head and face leads us to the conception of a long-headed stock which has to a greater or lesser extent permeated the island groups. This stock, often called Indonesian (resulting in much confusion), is better called Nēsiot. It is difficult if not impossible to isolate the type, for it has everywhere been mixed with round-headed yellow men. Haddon suggests that the Nēsiot type is short (60–62 in.), mesaticephalic—probably originally dolichocephalic—with black hair often tinged with red; skin tawny to rather light brown; "lozenge-shaped face, cheek-bones sometimes projecting; nose often flattened, sometimes concave."[1] The Murut of Borneo (C.I. 73) probably contain as much of this Nēsiot blood as any other island people.

Lastly, we must remember that the Mongols have crossed the Pacific, *via* Behring Straits and the neighbouring islands, and peopled America.

The Negro Race

The Negro race has two great branches, an African or Negro, and an Oceanic or Melanesian. In connection with both these great areas there exist negroid jungle folk of diminutive size and of much lower culture than their taller neighbours; these are the Pygmies, or Negritos, whose African representatives are often called Negrillos.

There is no satisfactory evidence as to the cradle-land of the Negro race, nor is the relation of Negro to Negrito at all clear in the natural history of man. While some authorities regard the Negritos as having

[1] *The Races of Man.*

arisen from their taller neighbours (by what can only be called degeneration) this view is not generally accepted and in fact seems untenable; rather should they be considered to represent an early human type, "infantilistic" both physically and mentally.

Although it is broadly true that the whole of Africa south of the Sahara is inhabited by "Negroes," by far the greater number of these (Nilotes, half-Hamites, Bantu) are not pure Negroes but carry more or less of Hamitic blood, the true Negro being confined to West Africa in the neighbourhood of the Guinea coast. The true Negro is tall (68 in.), woolly-haired, with a skin so dark that it is often described as black; stoutly built, short-legged, long-armed; the head dolichocephalic (C.I. 73–75); the face often prognathous, with thick everted lips; forehead often bulging, and nose platyrrhine.

The Oceanic Negroes are represented in their purest form by the Papuans, an obscurely variable stock with black woolly hair, skin dark chocolate or sooty brown; usually of medium stature; long-headed and broad-nosed, often with retreating forehead and prominent brow-ridges. Their stronghold at the present day is New Guinea; formerly no doubt they had a wide distribution in Melanesia, probably in Australia, and were present as a variety in Tasmania.

The Negrito are the peoples generally termed Pygmies. They are very short, dark-skinned, woolly-haired, broad-nosed, mesaticephals or brachycephals. In the east they include the Andamanese (st. 58½ in., C.I. 83), the Semang of the Malay Peninsula (st. 60 in., C.I. 79), the Aeta of the Philippines (st. 58 in., C.I. 82), and the little-known Tapiro of Netherlands New Guinea (st. 57 in., C.I. 79.5). In the west the African Negrito (Negrillo) of the Equatorial forests (Akka, Batwa, etc.) are the shortest of mankind (st. about 54 in.); they are mesaticephalic, with hair less dark than the eastern Pygmies, short in the trunk, with long arms and legs, and features tending to infantile type.

The Bushmen are probably to be related to the Pygmies, though their skin colour is yellow and their average stature 5 ft. or just over. Head mesaticephalic, face flattened, orthognatic, with prominent cheek-bones and very wide nose. The women tend to exhibit that peculiar development of fat on the buttocks which is called steatopygy.

The Hottentot is in many respects a magnified Bushman brought about by an infusion of Bantu and Hamitic blood (st. 63 in.). The women are frequently steatopygous.

The ears are often lobeless in both Bushmen and Hottentots.

The Australian Race

The Australian race includes the Australians and the pre-Dravidian tribes of Southern India and Ceylon (Vedda), the Sakai of the Malay Peninsula, and probably the Toala of the Celebes, though these latter seem to have absorbed much foreign blood. Throughout the race the hair is black, wavy or tending to curly.

The Australians are of medium height, with an average stature around 65½ in., but varying in different groups; the skin is a dark chocolate brown, often very hairy; the head is long, with flat retreating forehead

and prognathous jaw, the brow-ridges prominent (often excessively so), the nose depressed at root and often very broad.

The Sakai are short, with a stature scarcely reaching 60 in.; a reddish tinge in the hair; skin yellowish to dark brown; skull mesaticephalic (C.I. 78); nose high mesorrhine.

The Jungle tribes of Southern India (Kurumba, Irula, Paniyan, etc. and Ceylon (Vedda, almost extinct), are short (60–62 in.) dolichocephals (C.I. 70–75), often with prominent brow-ridges and nose generally platyrrhine. The hair may be frankly curly (Kadir and Paniyan, in whom Negrito influence is possible).

EUROPE

Disregarding the remains of palæanthropic man found in Europe and dating back to the lower and middle palæolithic, "neanthropic man" as we know him—the *Homo sapiens* of Linnæus—appears in the Aurignacian period, *i.e.* at the beginning of the Upper Palæolithic. All these were long-heads (though certain undescribed skulls of high mesaticephals have been stated to be of Aurignacian date). Round-heads do not appear until epipalæolithic (mesolithic) times, when their remains are found at Furfooz (Belgium), Offnet (Bavaria), and Mughem (Portugal); presumably these were the vanguard of the present-day European roundheads constituting the Alpine race of Central Europe, but we know little of the early history or spread of this race.

Coming to the New Stone Age, we find the coasts of the Mediterranean and the coastal areas of Western Europe populated by a rather short narrow-headed race, who as they spread over France and much of the British Isles introduced the megalithic culture[1] into Western Europe. They and their descendants are of the Mediterranean race. We do not know at what date this race entered Europe, but its Egyptian representatives in the Nile Valley—the predynastic or proto-Egyptians—were a flourishing agricultural people as early as the fifth millennium B.C. Following Haddon, we may assume that there was a great influx of Alpines into Europe about this time, indeed "we may reasonably conclude that Alpine man introduced into Europe cultivated grains and fruits, domestic animals, polished stone implements, painted pottery, weaving, and possibly at a later date the art of metal-working. It was to them that the lake-dwelling cultures were due, and mainly also it is to their descendants that we owe the Hallstatt and the La Tène [Iron Age] cultures, but both these were strongly influenced by the culture brought by tall, fair, long-headed Nordic man from the northern plains of Europe. . . ."[2]

The origin and early history of the Nordics is unknown, but their homeland is generally considered to have been the South Russian steppes or in their neighbourhood. One view regards them as a giant blonde variant of Mediterranean man, a change supposedly analogous to that

[1] By megalithic culture is meant a culture in which structures composed of large, usually rough, unhewn stones play a prominent part. Dolmens, circles, and triliths are common examples of megalithic monuments.

[2] *The Races of Man.*

in the brown bear which gave rise to the polar form. Whether this be so or not, we may agree that an early steppe-folk of Eastern Europe and Western Asia had been spreading westwards at various times and in different culture phases, and some of these "proto-Nordics" may be supposed to have passed northward into Scandinavia to become the ancestors of the Nordics of our own times.

The ethnology and history of Europe are the ethnology and history of these races, and the crosses that arose from them, with that of certain invading groups in historic times. Of the latter the only important invasions were those into Hungary and the Balkan Peninsula, bringing into Europe three Turki peoples, the Magyar, the Osmanli Turks, and the Bulgars. The two former have kept their Asiatic languages, and the Magyar have become completely European in physique and culture, the most prevalent physical type being described as somewhat brunette with chestnut hair and light eyes; the cephalic index is high (84), with a medium stature of 64 to 65 in. As regards the Turks, an ethnically mixed Turki nation settled down in Asia Minor in the eleventh century, but the earlier inhabitants were by no means exterminated; on the contrary, while great numbers embraced Islam, "many thousand children were marked by the knife of circumcision, and many thousand captives were devoted to the service or the pleasures of their masters."[1] It is the descendants of these already mixed Turks, modified by centuries of intermarriage with the European population of the Balkan peninsula, that constitute the European Turks of the present day, so that it is no wonder that in appearance they retain but little of their Asiatic origin.

The Bulgars, who reached their present homes in the seventh century, have become completely Slavonicised, but their speech contains more words of Turki origin than any other Slav language.

Though we neglect the other European peoples and nations as being too well known to be of interest in a summary account, some mention must be made of the Basques, if only on account of the quantity that has been written about them. Occupying the western Pyrenean provinces of France and Spain, it is said that sixty years ago there were perhaps half a million people who spoke their extraordinary language and who had until then succeeded in maintaining intact much of their peculiar politico-social organisation :—

"Their political institutions were ideally democratic. . . . In Vizcaya, for example, sovereignty was vested in a biennial assembly of chosen deputies, who sat on stone benches in the open air under an ancestral oak-tree in the village of Guernica This tree was the emblem of their liberties. A scion of the parent oak was always kept growing near by, in case the old tree should die. These Basques acknowledged no political sovereign; they insisted upon complete personal independence for every man; they were all absolutely equal before their own law; they upheld one another in exercising the right of self-defence against any outside authority, ecclesiastical, political, or other; they were entitled to bear arms at all times by law anywhere in Spain; they were free from all taxation save for their own local needs, and from all foreign military service

[1] Gibbon, chap. lvii., quoted by Keane.

and in virtue of this liberty they were accorded throughout Spain the rank and privileges of *hidalgos* or noblemen."[1]

Their language is agglutinative (the ordinary European languages are inflective), different meanings being expressed by the compounding of several words into one; thus the verb includes all pronouns, adverbs and allied parts of speech, and the noun similarly comprehends the prepositions and adjectives. A classical example, given by Ripley, meaning "the lower field of the high hill of Azpicuelta" runs, *Azpilcuelagaraycosaroyarenberecolarrea*. The antiquity of this curious language is denoted by the slight development of the principle of abstraction or generalisation, "Thus there is said to be a lack of such simple generalised words as 'tree' or 'animal.' There are complete vocabularies for each species of either, but none for the concept of tree or animal in the abstract,"[2] a condition paralleled by numerous primitive peoples, *e.g.* the Cherokee, who are said to have thirteen words to signify the washing of different parts of the body but none for the idea of "washing" itself. The crudity of the verb is another primitive feature, most Basque verbs being in fact nouns (*e.g.* "to give" is treated as if it were "donation" or "the act of giving") and declined as such.

As to its origins, and the affinities of the people who originally spoke it, nothing is known. The idea that Basque is an Hamitic language akin to Berber has broken down, and we are left with the bold and seductive suggestion of Elliot Smith that it represents the speech of Upper Palæolithic man.

Physically there is no uniformity among the Basques at the present day; dolicho- or predominantly mesaticephalic in Spain, they are brachycephalic in France. Nevertheless a good case can be made out for a definite round-headed long-faced type, with a bulging forehead and refined oval jaw, which it is suggested may have developed *in situ*, and, if so, then no doubt as a result of interbreeding and selection.

Examining the temperament of the three great European races in relation to Jung's behaviour types (introvert and extravert), it seems that though the Nordic race excels other races in determination, this steadfastness shades into stubbornness which, in the individual, is likely to lead to recklessness as to the results of his actions not only to himself but to others. His power of organisation is of great social value and, with his fighting capacity, accounts for his genius for imposing himself as an aristocracy dominating other peoples; nevertheless he is essentially an individualist, and as such shows a definite incapacity to understand and sympathise with views not his own. However his natural reserve prevents his thrusting his views on others, *i.e.* his general attitude is introvert. McDougall says he is "weak in herd instinct." It would be more accurate to say that his "herd" tends to be small; indeed there is abundant evidence of this in the sagas, wherein we may find Nordic traits more vividly portrayed than anywhere else. It seems that it is this individualism, (with perhaps a certain capacity for mysticism), which in the religious sphere has led to that protestant tendency, which contrasts so sharply with the dominant catholicism not only of Mediterranean but of Alpine

[1] Ripley: *The Races of Europe* (1900). [2] Ripley: *op. cit.*

lands. The Nordic "is distinctly religious and philosophical, but his yearnings, not being easily satisfied, tend to drive him beyond the actual and into mere metaphysic."[1] Nevertheless, he has an undoubted aptitude for science which is, perhaps, reinforced by a capacity for observation that seems to go with his love of the sea and of the country as opposed to the town. It is these last qualities, combined with his individualism and pugnacity, that have made him the finest explorer and coloniser in the world.

The Alpines of Europe are predominantly Catholic, and lack the stubborn individualism of the Nordics, while it is generally agreed that they are specially suited to life in small communities and show little tendency to adventure and colonisation, and it is alleged that with this there goes a relative absence of genius or outstanding ability. A certain quality of moroseness has been attributed to the Alpines; if this be so, another aspect of this quality might be the steadfastness and capacity to bear punishment which the Swiss wars of independence showed them to possess.

The Mediterranean race has been described as vivacious, quick, impetuous, impulsive; with emotions blazing instantaneously into violent expression and action. This may be true as it stands, and no doubt the Mediterraneans generally are extravert, though if, as is generally stated, the South Italians—the most pronounced Mediterraneans of the group—will coolly shape their actions for years towards the consummation of a vendetta, the description is perhaps somewhat exaggerated. The Mediterraneans show an intense appreciation of colour, glitter and movement and there is no doubt as to the important part played by coloured illustrations in their papers, even at a time more than a quarter of a century ago when colour was but sparsely used in Western European journals. It would be interesting to know whether this applies alike to Italy and Spain and whether it is equally true of Northern and Southern Italy. Whatever conclusions we may come to concerning the above, it can hardly be denied that the Mediterranean race has actually more achievement to its credit than any other, since it was responsible for by far the greater part of Mediterranean civilisation, certainly before 1000 B.C. (and probably much later). We know little of the physical characters of the Hellenic Greeks, but may regard them as basicly Mediterranean, with a strong admixture of Alpine and no doubt some Nordic. Thus the Mediterranean race shaped not only the Ægean cultures[2] but those of Western as well as the greater part of Eastern Mediterranean lands—including the Sumerian civilisation of Ur and Kish—while the culture of one branch, the Hamitic pre-dynastic Egyptians, formed the basis of that of Egypt. Rome is purposely omitted on account of the doubt there is as to the ethnic relationship of the Romans, some holding that patricians and plebeians were of different race and contributed vastly different proportions to Roman civilisation.[3]

[1] F. Lenz, in Baur—Fischer—Lenz: *Menschliche Erblichkeitslehre* (Munich, 1923).

[2] Actually the earliest Cretan skulls known dating 1500 B.C. and earlier are not exclusively long-headed.

[3] The alternate views are well set out in William Ridgeway, "Who were the Romans?" (*Proceedings of the British Academy*, 1907) and H. J. Rose, "Patricians and Plebeians at Rome" (*Journal of Roman Studies*, 1922).

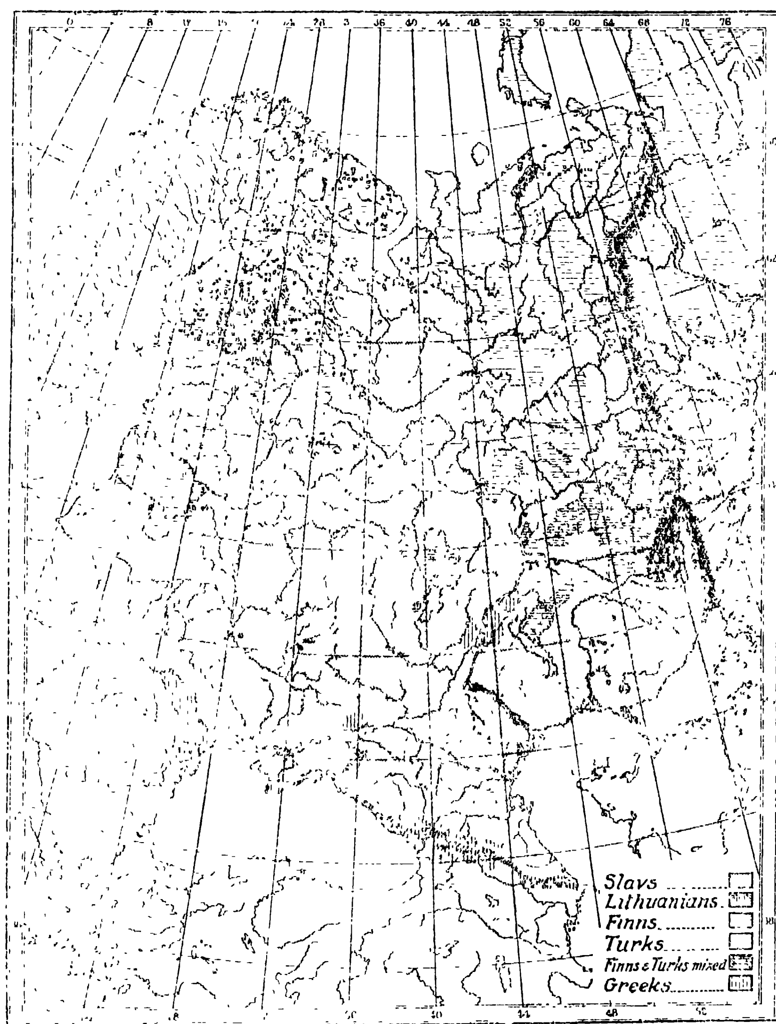


Fig. 3.—ETHNOLOGICAL MAP OF RUSSIA IN THE NINTH CENTURY

ASIA

The vast continent that we call Asia should, from the ethno-historical standpoint, be yet further enlarged to include almost the whole of European Russia, for it was only in the ninth century that that branch of the Alpine race that we term Slavs began to push into its dark forests, until then inhabited by Ugro-Finnish tribes speaking non-Aryan languages, whose representatives, now predominantly of European blood, include,

e.g., the Zyrian, Mordven, and Votyak of present-day European Russia, all still speaking their own languages.[1] In connection with this persistence of Asiatics in a country that from our schooldays we have regarded as European, it should be emphasised that the Urals, which on the map appear as a well-marked natural barrier between Asia and Europe, are but rounded hills with many intervening gaps, nowhere attaining a height of over 5,500 ft. (*see Fig.* 3).

The early history of man in Asia is entirely unknown. Implements of River Drift type are abundant in some parts of Western Asia and in India; a Mousterian skull has been excavated in Palestine, and the Far East has given us the remains of *Pithecanthropus*—the most primitive hominid known—and is now yielding the remains of numerous individuals of *Sinanthropus*; but these finds no more than prove the varying forms and wide distribution of Quarternary Man. Coming to more recent times, the Ainu show such clear evidence of Caucasian affinities that we can only regard them as undifferentiated progenitors or representatives of one of the European races, and though their skull is very different from the modern Alpine their appearance, summed up in oft-quoted resemblance to the Russian peasant, makes it reasonable to ally them to that race. The relation of the great group of Western brachycephals, which in its extended sense we call Alpine, to the yellow roundheads (the Mongolian race) is quite obscure.

The main geographical features of Asia, upon which depend the distribution and cultures of its peoples, are three great belts of country, each with more or less uniform features, running from east to west from the Pacific Ocean into Europe, and south of these a high steppe with two great series of plateaux—an eastern, including Tibet, Eastern Turkestan, and North-West Mongolia with the Gobi desert, and a western comprising Iran, Armenia, and Anatolia. Southward and peripherally lie India, Indonesia, and in the west Arabia, each with a history and ethnography of its own, the first and last of such size and importance as almost to constitute sub-continents in themselves.[2]

So much for generalisations. Turning to the Near East (Anatolia, Mesopotamia, Syria, but excluding Arabia), although there are indications that the aborigines were Mediterraneans, round-headed peoples from the East have poured in from so early a period that even in Crete our oldest skulls are not pure Mediterranean. On the other hand the skulls collected by Woolley at Ur, judged to date from the fourth millennium B.C., clearly indicate that the early Sumerians were Mediterraneans.[3]

Leaving for the moment the Near East, we may agree with Buxton to define a " Middle East," to include the Turkoman and Uzbeg Soviet republics in the north, and Persia, Beluchistan, and Afghanistan in the south.[4] This is an area of ethnic confusion : there is certainly a large element of Alpine round-heads, akin to or even identical with our European Alpines, and if it be admitted, as has been suggested, that the Turkoman Steppes are the area of characterisation of the Nordic race, then there

is no difficulty in understanding the mixed types of this area, particularly if weight be given to the presence of a Mediterranean type akin to the Dravidian, in connection with which we may remember that the Brahui of Baluchistan, though they are (now) physically Baluchi, speak a Dravidian language.

The Turki, whose physical characters are described on page 441, form the basis of the Eastern Turkish peoples, *i.e.* the Turks of East Central Asia—Kirghiz, Kasak, Uzbeg, Turkoman, etc. These folk are very mixed, differing considerably in social characteristics, and are very far indeed from any feeling of race solidarity such as that implied by the Pan-Turkish (Pan-Turanian) movement of the War years. Uzbeg seems to be a term of more political than racial significance, and the Kirghiz are said to carry much Mongol blood. Actually all these Eastern Asiatic Turks are to be looked upon as the remains of the old Turkic stock—greatly modified by infusion of foreign blood—first known to history as the Hiung-nu, whose inroads, together with those of the Tung-hu (Tungus), led to the building of the Great Wall of China during the Ts'in dynasty, thus forcing westwards the Asiatic *Völkerwanderung* of the first centuries of our era —a fact which, it is interesting to note, was appreciated by Gibbon some hundred and fifty years ago.

The Medes and Persians of history are regarded by Haddon as proto-Nordic, their blood still existing in the Farsi about Persepolis, " fair in skin, with abundant hair and beard of a dark chestnut colour, [though] real blonds with blue eyes are rare." [1] The other Persian type—tall, long-headed, and dark—is that which commonly represents people of importance in Persian paintings. On the other hand the " moon-faced " beauties perhaps represent the type that may most fairly be termed Iranian, the Alpine Tajik (Tajik, Galcha, etc.) with a C.I. of about 85.

Arabia, the home of the Semites (and probably of the Hamites too), falls naturally into three main divisions, a northern, a southern, and a third less well characterised central area between the Midian coast on the west and the head of the Persian Gulf on the east. The northern division extends to the edge of the Syrian desert, and, apart from its oases, is inhabited by nomad pastoralists, and furnishes a barely adequate pasturage for their limited numbers. The southern division contains the highlands of Yemen and Asir in the west, which, with the Hadramut, form a habitable zone round the great southern desert, continued to the east by Oman and Jebel Akhdar. The Yemen and Asir highlands enjoy a temperate climate; their population consists largely of agriculturalists, whose terraced hills form one of the most characteristic features of the landscape. The central zone includes El Hasa, Nejd, and the Hejaz, with the holy cities.

The population of the northern area—typical northern Semites—are with few exceptions dolichocephalic and narrow-nosed, with white skin easily bronzing, and of medium stature. They come nearest to the traditional Arab of the text-books, " with a fine oval face . . . [a] type which . . . often assume an almost ideal beauty." [2] In the south an entirely different type prevails: a " Beduin " tribe inland from Aden gives a

[1] Haddon: *op. cit.* [2] Keane: *Ethnology.*

cephalic index of 81, moreover the stature is lower than in the north, and an examination of all the figures for Southern and South-Eastern Arabia indicates that less than 10 per cent. are long-headed. We have very few measurements derived from the central area; provisionally we may regard its inhabitants as predominantly northern.

Obviously then, while the inhabitants of Northern Arabia are "Arabs" in the commonly accepted sense and true Semites, the southerners are not, and though we cannot be certain who they are, it is most probable that the round-headed element has come in from Mesopotamia, a suggestion supported by the fact that, long before the sixth century A.D. South Arabia was a country of a thriving civilisation with an agriculture so advanced that irrigation works on a considerable scale existed and were kept in repair for hundreds of years. It may be added that within the last two years Mr. Bertram Thomas, exploring the unknown country behind Oman, has found tribes who physically are of the South Arabian type but who speak Semitic languages that are definitely not Arabic.

Much romantic nonsense has been written on the temperament and character of the Arab. Arab loyalties are primarily to their group, *i.e.* to clan and family; the tribe comes next, and patriotism in the larger Western sense can only be described as uncommon. Where clan and tribal loyalty is all that is required by his environment the Arab lives happily enough, and his social organisation may be regarded as successful, as among the nomads of the Sudan and the Beduin of Arabia, but where government of larger or more coherent units is required he is apt to fail. Indeed on this matter the town Arab has few illusions, witness the Syrian proverb, "You cannot make a pair of tongs out of wood nor a Pasha out of an Arab." Generally religious, the pure-blooded Arab is less fanatical than is commonly supposed; it is the mixed breeds, in whom there is an infusion of Negro blood, that provide by far the greater number of fanatics. It was no matter of chance that the Mahdi was a Dongolawi and the Khalifa a Ta'aishi of the southern negroid cattle-Arabs (Baqqara) of Kordofan.

As might be expected, town folk, peasants, and nomads differ in habits and superficially in outlook, but they have a substantial fund of common characteristics. They may fairly be described as "polite, intelligent, very kind and affectionate to their children and relations, diligent in their own affairs, almost completely deficient in patriotism and public spirit . . . have considerable humour, are cheerful, excitable, extremely avaricious, always ready to bribe or take bribes, but otherwise fairly honest."[1]

Counterbalancing their avarice is a hospitality so generous as to have become proverbial. It is a fact that except in large towns where inns abound any stranger will be provided with food and refuge without thought of payment, the nature of his entertainment depending far more on his social position than on his wealth, and it is this hospitality, with the ready kindliness that accompanies it, that has made for the Arab so many admirers.

The Semites had overflowed into Palestine and Mesopotamia millenia

[1] Lord Raglan: "Arab Life and Character." (*Nineteenth Century and After*, 1922).

ETHNOLOGICAL MAP OF SIBERIA

Scale 100 0 200 400 600 Eng. Miles

Fig

before our era. The Canaanites are regarded as Semitic, but the Amorites are traditionally considered Nordic. The Abrahamic branch were nomads who entered Egypt with the Hyksos and, after these were expelled, entered Palestine, absorbing the former inhabitants into their politico-religious system but in the process themselves taking on, to a greater or lesser degree, the physical traits of the earlier peoples. Thus both Jews and Samaritans at the present day include light-eyed red-haired strains, and the typical "Jewish" nose is the Armenoid nose of the Hittites, the ancestors of the present-day Armenians. The Assyrians too were an Armeno-Semitic mixture—witness their characteristic faces as portrayed in the long series of bas-reliefs from Nimrūd, dating from the latter half of the ninth century B.C., in the British Museum in London.

The Jews of the present day are predominantly round-headed. They are grouped into two stocks, the Askenazim in Northern, Central, and Western Europe, and the Sephardim in the South and in Spain, Portugal, and North Africa.

In Siberia, a vast area concerning which comparatively little is known, it is convenient to employ a broad classification, such as that proposed by Czaplicka, into Palæo-Siberians and Neo-Siberians[1] (*see Fig.* 4). The first term is equivalent to the older term Palæo-Asiatic, and includes principally Chukchi, Koryak, Kamchadal, Gilyak, Yukghir, Yenisei, and Ostyak. All these, with the Ainu, may be regarded as very ancient peoples and generally as living a simple life, specialisation, so far as it goes, having mainly been forced upon them by the Arctic climate. But while it may be true that the Palæo-Siberians have been in Siberia for a prolonged period, the latest opinion is that they are a reflux from North-Western America, and the best authorities hold that their language is American-Indian rather than Asiatic, this incidentally being the only accepted example of relationship between Old and New World tongues.

The term Neo-Siberian implies no more than that we believe the Finnic, Mongolic, Turkic, and Tungusic tribes which have populated Siberia to be relatively recent incomers. Czaplicka, quoting Patkanoff, gives a complete list of these tribes, of which all belong to one or other of the following stocks :—Finnish, Samoyed, Turki, and Tungus.

These Palæo- and Neo-Siberians are the inhabitants of the tundra and tayga, the two more northern of the belts referred to on page 451. They are all more or less reindeer pastoralists, though some of the Chukchi and Gilyak are too poor to possess any and maintain a miserable existence dependent on other groups. Other Chukchi, and, for example, the Koryak, have large herds of semi-feral animals that cannot be milked and are of little use for transport, but are invaluable as meat and trade. Many Tungus have good herds of reindeer, but may consider them too precious to use freely as food, especially as hunting, fishing, and trading are widely practised by this people, while the Samoyedic tribes are generally pure pastoralists, living on the milk and flesh of domesticated deer. Reindeer herdsmen probably live a harder life than any other pastoralists and require really large flocks, for ten deer are said to give no more milk than one cow.

[1] *Aboriginal Siberia* (1914).

The Low Steppe east of the Lena is mainly in the hands of Tungus and Yakut; west of the river are Ostiak "Tartars," *i.e.* Turki and Turki-Mongol folk, and such important Turki peoples as Turkoman, Kirghiz, and Uzbeg, with a broad zone of Russian settlement extending from Saratov through Perm in a south-easterly direction.

Most of the pastoral tribes of steppe and tayga, though they occupy such a vast area, can be passed over with what we have already said, but the Tungus are most important. They stretch beyond the limit of Siberia to include, *inter alia*, many Manchu, the Buriat (of Lake Baikal), a number of tribes of the Gobi area, the Kalmuk (Chinese Turkestan, Mongolia, and Zurgaria), and the Taranchi of Eastern Turkestan. Naturally, so far-flung a people exhibit considerable variation physically, yet in a general way they conform to the characters given on page 444, *i.e.* they are high brachycephals (C.I. 84.8), of medium stature (62½-66 in.), with yellow or yellowish-brown skin, hair coarse, straight, and sparse, broad flat face and prominent cheek-bones, broad nostrils and dark brown eyes, usually typically " Mongolian."

The Tungus are praised by every traveller for their qualities and character. They are described as " cheerful under the most depressing circumstances, persevering, open-hearted, trustworthy, modest yet self-reliant, a fearless race of hunters, born amidst the gloom of their dense pine-forests, exposed from the cradle to every danger from wild beasts, cold and hunger. Want and hardships of every kind they endure with surprising fortitude."[1] This, of course, only applies to the wilder hunting and reindeer Tungus; the Manchu, the southern, civilised and settled section of the stock, until recently kept up the old clan system under military organisation into " banners," which enabled them to conquer the Chinese in the seventeenth century and to impose upon them the Ch'ing dynasty, which endured until 1911.

The ethnology of Japan is one of the puzzles of anthropology. Not only are we unable to make any definite statement as to who the Japanese are, but the most critical philologists cannot cite any linguistic stock to which the Japanese language is affiliated. We say " critical " advisedly, for many statements exist, but none so far has stood the test of time.

Considering the Japanese as a nation, we may say that they have an average stature of 63¼ in., and a cephalic index of 81.8, but this really gives little idea of the people. Two distinct types, each perfectly characteristic, are immediately obvious. A coarse type, short and thick set, with broad flat face, narrow and oblique eye, and typically a well developed epicanthus, a dark tawny-olive skin and the nose often concave; this is obviously a thoroughly Mongol type. In opposition stands the " fine," or Daimyo type, taller, of slender build with long face and often long nose, the latter sometimes prominent and arched, with the tip somewhat flattened down, recalling vaguely the Armenoid form, though certainly not to be given this term. This aristocratic type—familiar in countless colour prints—was known, admired, and represented in sculpture as long ago as the seventh or eighth century, for the wooden statue of Prince Shōtoku Taishi at Nara admirably represents it, as does a pottery figure of a

[1] Keane: *Asia* (1906).

cavalryman, probably of rather earlier date, recently excavated in Korea.

The earliest inhabitants of Japan were the Ainu, still existing in Yezo, North Island, and the anthropologist travelling in Japan will soon feel convinced that even in the south where the historic "Japanese"—whoever these were—first landed there is far more Ainu blood than the text-books imply. Wavy hair (as in the Ainu) is not very uncommon, curly hair occurs, and there is often a rosy flush in the complexion which, if not so marked as that of the Ainu, does strongly recall it. That the Ainu exterminated an earlier people, the Koropakguru, the "Earth-Spiders" of Japanese legend, is now generally discredited, and the Ainu must be regarded as the true aborigines. With them there mingled incoming round-headed Asiatics, indeed some of the shell mounds contain both Ainu and Asiatic skulls of the same date.

A southern strain from the Indonesian islands has been generally recognised, and there seems to be cultural evidence for this. The often-alleged Negrito strain seems much more doubtful; in fact the writer of this Article would discredit it. It is true that the traveller is struck by the fact that he meets a certain number of very short Japanese, but the stature of the Japanese has been carefully studied, and although a certain number (under 5 per cent.) are under 60 in., there is a larger number (over 6 per cent.) of tall subjects ranging from 67 to 70¾ in. Further, while carefully on the lookout for individuals with negroid features, the writer failed to find even a single subject.

But whatever the stocks that have gone to produce the Japanese people, the result is noteworthy and, if often puzzling to the Westerner, is generally admirable, even if recent foreign influence has not always led individuals to show themselves at their best. Cheerfully patriotic in belief in their country and themselves, with a high sense of honour, the Japanese have in an eminent degree the qualities of citizens and patriots combined with a rare capacity for united action. This genius for co-operation, so well seen in business and politics, is one of the characters that differentiate them from the only other Eastern people of equal capacity and civilisation, for, in spite of the wisdom, business sagacity, and individual success of particular Chinese, the latter have so little power of combination that they have not produced a single great banking house or business firm, as have the Japanese in numerous instances, while the same opposed characteristics inform and shape the politics of these two great peoples. To say, as is sometimes said, that the Japanese are irreligious is untrue. They are definitely a religious people—it is only necessary to go to one of the big temples on a Buddhistic festival to appreciate this—but their religion is cheerful and assumes primitive virtue rather than original sin; even in the insanities, delusions of a religious nature with sense of guilt, so common in this country, are practically absent in Japan. But this by no means implies the absence of religion. The bravery and persistence under torture of considerable numbers of the Christian Japanese in the seventeenth century must surely be attributed to nothing else than strong religious feeling. What does strike the Westerner reading Japanese history and talking to the older men is how efficiently the sense of decorum, with the typically Japanese appreciation of æsthetics, seems to have guided every rank. It may be said quite fairly that the influence of Buddhism as a code

was more æsthetic than ethical. So Japanese feudalism converted the Buddha's doctrine of renunciation into the stoicism of the warrior; the Japanese Samurai renounced desire not that he might enter Nirvana, but that he might acquire the contempt of life which would make him a perfect warrior.

As to the arts and crafts, it can scarcely be doubted that the Japanese are gifted *en masse* with an æsthetic sense which makes it fair to write of them as the most art-loving and art-appreciating of mankind, and, even if they owe the beginning of their arts to Chinese teachers, there is not a single branch that they have not thoroughly made their own—to such an extent indeed that origins are in most cases established by historical knowledge, rather than immediate similarity.

Politically, besides China proper, *i.e.* "the eighteen provinces," China rules or exercises suzerainty over Chinese Turkestan, Mongolia, and Tibet. Here we shall only consider ethnic China, bounded for practical purposes on the north by the Great Wall, and, where this leaves off, by the Gobi Desert. In the west is the mountainous Tibetan border, while in the south-west to the Gulf of Tonking the boundary is political rather than natural.

Historically we know nothing of the origin of the Chinese, though, as already stated, in Kansu and Honan there have been found burials of neolithic and transitional (chalcolithic) date of a people who were Northern Chinese in physical characters but differed culturally from almost all that we know of Chinese culture. These folk may date to some 2000 B.C., whereas the earliest Chinese (An Yang) culture, ivories, etc., carved in the style of the Chou dynasty, dug up in the neighbourhood of this site, may be taken to be nearly a thousand years later. Too much importance must not be attached to these dates; that of the Kansu burials is speculative, moreover these pre-Chinese burials and An Yang are geographically far apart.

In any case, the old civilisation of China is first known in the valley of the Hoang Ho—the Yellow River—and here, in Northern China, is the home of the rather tall, often burly, Chinese, who, unless their type has altered within the last two to three thousand years, started China on her voyage of pre-eminence in Asia and were the originators of those wonderful bronzes and porcelains which the name of their country calls to our minds.

These northerners are stoutly built men, with an average stature of about 66 in., mesaticephalic rather than brachycephalic, though not uncommonly described as round-heads. They vary greatly in facial characters; long faces and noses with high bridges are not uncommon, nor is the eye always Mongolian. They may be presumed to carry a substantial amount of foreign blood; Tungus, Turki, and Mongols from beyond the Wall have entered Northern China over and over again, and, though always absorbed into the Chinese nation, have doubtless modified the type.

This great historical civilisation spread into Southern China along the tributaries of the Yangtsze, but did not greatly affect the folk inland from its southern bank until the last centuries of the last millennium B.C.

Before this we must picture the southern Chinese as leading a somewhat primitive agricultural life, indeed the quality of the culture they held at that time may be fairly well judged by that of the fast diminishing group of so-called " aborigines " of the Southern Provinces—the Man, Miao, etc.—who again differ little from the folk of Indo-China and even the T'ai of Burmah.

The southern Chinese, whose physical characteristics are less well-known than those of their northern brethren, are considerably shorter, more round-headed, and rather darker-skinned. We may put their height at about 63–64 in., their cephalic index as somewhat over 80, and note that the back of the skull often shows considerable occipital flattening.

The Manchu in China have so intermarried with the Chinese that it seems doubtful whether they can be differentiated physically, and even in the north beyond China proper the Manchu are a little-known people. They have mixed much with Chinese and latterly there has been Japanese immigration; the figures given are often discrepant, and Buxton argues the necessity for search for an old Manchu type in the remoter parts of Manchuria.

The " Turki " Moslems of Kansu are regarded by Buxton as an Alpine-Yellow race cross, and probably have much Turki blood; they are of heavier build than the ordinary Chinese and more turbulent. Besides these " Turki " Moslems there are " Arab " Moslems in Peking, forming a distinct community dating back to the founding of the city by Yung Lo (reigned 1403–1425). They are sufficiently good Moslems to avoid pig, and this, in China, implies that their marriages are limited to their own community.

In spite of limits of space, something must be said about the temperament and character of the Chinese, so different from that attributed to them by the uninstructed layman. Their outlook indeed is as far as may be from the inscrutable, unemotional, silkily subtle quality which Western ideas—and especially Western fiction of the cheaper sort—attributes to them. It is only necessary to watch a group of Chinese coolies seeking for hire, or a crowd brought together by a street mishap, or even labourers at their work, to be convinced that the Chinese are more excitable and emotional than north Europeans. In private life the same excitable character is shown by the very emotional conduct which is common after family quarrels, and the frequency on such occasions of severe hysteria and suicide, while with regard to the suggestibility of Chinese crowds it is sufficient to refer to the history of the Boxer Rebellion.

This is not to say that the " superior man " of Confucius does not exist; there is still a considerable number of men who have trained themselves to control their emotions in true Confucian fashion; nor indeed are such limited to the older-fashioned *literati*. But their number is relatively small, and the mass of Chinese are at least as emotional as the corresponding classes in Great Britain or the United States. Perhaps the diplomatist—even if he was mythical—who called the Chinese the " British of the East " was not far wrong. It is at least a pretty, and we may hope not utterly unfounded, compliment to two peoples, even if one essential difference in outlook be kept in mind. The Chinese has never admired

the fighting man as such, his heroes are not soldiers, and if in history soldiers have earned distinction it was for administrative rather than fighting virtue. So his poems are not epics, nor are his love romances of Western erotic type, for his whole outlook on womankind is as different as may be from that of the mediæval and Renaissance Europeans who have so largely moulded our tradition.

The Jews of China are of historical interest only. They are now assimilated, but at one time they formed a small but definite element at Kaifeng and had a synagogue.

In a concise description such as this, Tibet, Mongolia, and Manchuria are conveniently, if somewhat irregularly, considered as Chinese borderlands, and indeed in all these regions Chinese influence has existed for the last 2,000 years or more.

Tibet is officially so connected with China that it is symbolised by one of the five stars in the flag of the Republic. Little is known of the country anthropologically, but we have already referred (p. 443) to the presence of old Caucasian blood. Further, two types can be recognised; one long-headed, the so-called "Warrior" type, the other round-headed, the "Priestly" type, though as might be expected both types are found among the priests, and moreover, in Northern Tibet Chinese influence has been potent for generations, bringing with it no doubt considerable Chinese blood.

The Mongols, who have given their name to the numerically strongest of the human races, have their home in a huge, sparsely inhabited country to the north of China. Very little is known about them anthropologically, but, after examining the available evidence, Buxton concludes that "there seems to be an underlying homogeneous element among the people who claim to be Mongols; this is probably, especially on the borders, mixed with other strains, but is essentially different from Yellow or Mongoloid man. Their territory has been invaded by Yellow man, who has at times mixed much with the population, and to-day often exists in groups within Mongol territory, but is always physically and culturally distinct. The Mongols are connected by blood with some branch of Alpine . . . man."[1]

South-east of China lie Tonking, Annam, Cochin China, and Cambodia (constituting French Indo-China), Siam and Burmah. It is probably true that over all this area, and especially in Indo-China, the dominant type is one akin to the "aborigines" of Southern China, and we may regard these "southern aborigines," if we may call them so (omitting for the moment pre-Dravidians and Negritos), as having been modified locally by strains of Negrito, Tibetan, Nēsiot, and even Caucasian blood, *via* the Tibetans. Farther south, in the Malay Peninsula, besides Malays there are Semang (Negritos), Sakai (pre-Dravidians), some primitive proto-Malays (Besisi and Jakun) and immigrant Chinese.

The Malay proper, the true Malay of history, who distinguish themselves as the Orang-Maláyu, are Muhammadan and speak the language

[1] *Op. cit.*

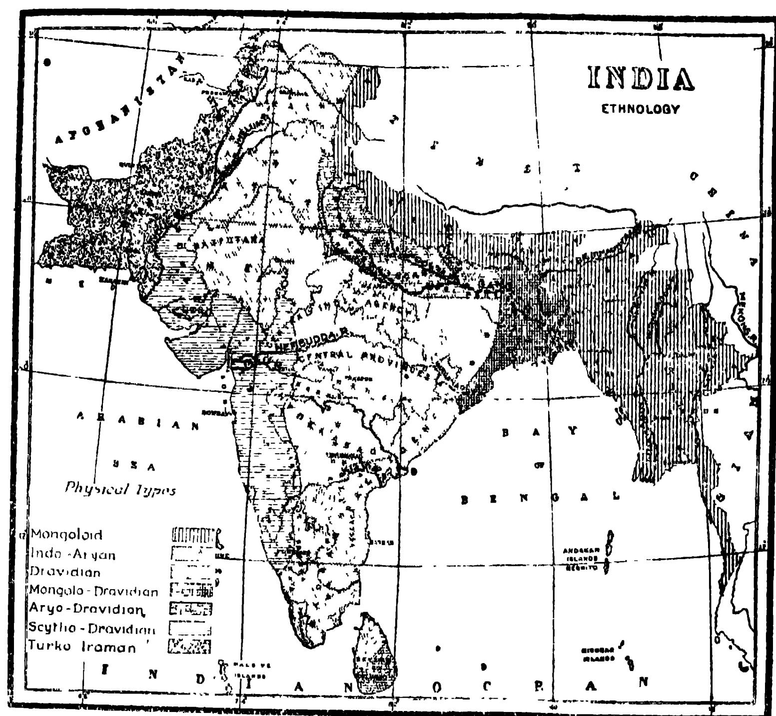


Fig. 5.—RACES OF INDIA (AFTER RISLEY)

that is called Malay. They appear in history about the middle of the twelfth century, originating as an obscure tribe which rose to power in the Menangkabau district of Sumatra. At this time was founded their first colony, Singapore; its name, which is pure Sanscrit, signifying the "Lion City," is an indication of the strength of Hindu influence in the Archipelago at that time. Menangkabau was the first Moslem state to acquire political supremacy, and "this district thus became the chief centre for the later diffusion of the cultured Malays, their language, usages, and religion, throughout the Peninsula and the Archipelago. Here they are found in compact masses chiefly in south Sumatra; in all the insular groups between Sumatra and Borneo; in the Malay Peninsula as far north as the Kra Isthmus, here intermingling with the Siamese . . . partly Buddhists, partly Muhammadans; round the coast of Borneo and about the estuaries of that island; in Tidor, Ternate, and the adjacent coast of Jilolo; in the Banda, Sula, and Sulu groups; in Batavia, Singapore, and all the other large seaports of the Archipelago. In all these lands beyond Sumatra the Orang-Maláyu are thus seen to be comparatively recent arrivals; and in fact intruders on the other Malayan populations, with whom they collectively constitute the Oceanic branch of the Mongol division."[1]

[1] Keane: *Man, Past and Present* (1920).

It is these "other Malayan populations" which constitute the great mass of "proto-Malays," whose most highly civilised members, such as the Javanese, practise a culture largely derived from India and differ *toto cœlo* from the rude up-country tribes of Borneo.[1]

Geographers sometimes divide India into three great areas (the Deccan in the south, north of this the plains of Hindustan, and then the Himalaya and their foothills), but these do not correspond to natural ethnic provinces. The anthropology of India is in fact difficult, and our knowledge is quite inadequate. We may assume that the oldest population was pre-Dravidian, whose representatives, the primitive hunting jungle tribes of India (in the Deccan Irula, Kuramba, Paniyan, etc.) and Ceylon (Veddas), still exist. It is probable that such primitive hunters formerly extended over the greater part of India, and though the existence of Negritos has never been proved in the sub-continent, their former presence in the Deccan seems likely.

The more advanced population of India has been divided by Risley into seven great groups, and although his classification has been criticised, it cannot be said that the types he set up have been seriously impugned, though it may fairly be urged that his nomenclature is not always fortunate (*see Fig.* 5). Risley describes his types, passing from the western frontier of India; in our description it will be convenient to start in the south with the Dravidians, a very old element in India. Apart from pre-Dravidians and hypothetical Negritos, the Dravidian may be taken to represent the ancient civilised population of much of India, its dilution with pre-Dravidians and its modification by Caucasian Aryan-speaking and Mongolian elements producing the Indians of the present day.

The *Dravidian* type extends from Ceylon to the valley of the Ganges, pervading the whole of Madras, Hyderabad, the Central Provinces, most of Central India, and Chota Nagpur. Among its most characteristic representatives are the Paniyans of the South Indian hills and the Santals of Chota Nagpur. The stature is short or scarcely medium; the complexion very dark; the hair shows tendency to curl; eyes dark; head long, and nose very broad.

The *Mongolo-Dravidian* type, found in Lower Bengal and Orissa, comprises the Bengal Brahmans and Kāyasths, the Muhammadans of Eastern Bengal, and other groups peculiar to this part of India. They are to be regarded as a blend of Dravidian and Mongolian elements, with a strain of Indo-Aryan blood in the higher groups. Stature medium, complexion dark; hair on face usually plentiful; head broad, nose medium with a tendency to breadth.

The *Aryo-Dravidian* type, found in the United Provinces of Agra and Oudh, in parts of Rajputana, in Bihar and Ceylon, is represented in its

[1] By continental writers the inland (pagan) tribes of Borneo are known as Dyak; in this country the term is commonly limited to a particular tribe, the Orang-Iban, the so-called Sea Dyaks, though there also exists a numerically weak and insignificant tribe termed Land Dyaks. As to Indian influence, it is worth remembering not only the ruins of Borobodur, but that Bali is still administered (under Netherlands authority) on the model of a Hindu rajarate.

upper strata by the Hindustāni Brahman, in its lower by the Chamār. Regarded as arising from the intermixture of Indo-Aryans and Dravidians, the former element predominates in its lower groups and the latter in its higher. The stature is medium ; the complexion varies from lightish brown to black ; the head is long, with a tendency to mesaticephaly ; the nose ranges from medium to broad.

The *Scytho-Dravidian* type of Western India, comprising the Marātha Brahmans, the Kunbis and the Coorgs, was thought by Risley to have arisen as a mixture of Scythian and Dravidian elements. There is really no evidence for the identity of the round-headed group, who must however fall within the Alpine race. Hair on head rather scanty; stature medium; complexion fair; head broad; moderately fine nose, not conspicuously long.

The *Mongoloid* type of the Himalaya, Nepal, Assam and Burmah, is represented by the Kanets of Lahoul and Kulu, the Lepchās of Darjeeling, the Limbus, Murmis and Gurungs of Nepal, the Bodo of Assam, and the Burmese. Stature low or medium ; skin of varying tints of yellowish brown ; head broad, with face characteristically flat ; nose fine to broad ; eyelids often oblique ; facial hair scanty.

The *Indo-Aryan* type occupies the Punjab, Rajputana and Kashmir, having as its characteristic members the Rajputs, Khatris and Jats. This type most nearly approaches that traditional for the Aryan-speaking colonists of India. The stature is mostly tall ; complexion fair ; hair on face plentiful ; eyes dark ; head long ; nose narrow and prominent.

The *Turko-Iranian* type is represented by the Baloch, Brāhui, and Afghāns, of the Baluchistan Agency and the North-West Frontier Province. Risley writes of these peoples as " probably formed by a fusion of Turki and Persian elements in which the former predominate,"[1] but there is also an Armenoid strain. Stature above mean ; complexion fair ; eyes mostly dark, but occasionally grey ; hair on face plentiful ; head broad ; nose medium, prominent, not infrequently Armenoid.

Perhaps the most important of the objections that have been raised is that the broad-headed element in Risley's Mongolo-Dravidians and Scytho-Dravidians is due to an admixture of the Pamir type of the Alpine race. This is no easy matter to settle ; it can only be said that the origin of the Mongolo-Dravidians has been critically examined by Buxton,[2] with the result that he supports Risley's thesis, while the profile of some Bengali faces can scarcely fail to convince that at least some Mongolian blood is present. With regard to the Scytho-Dravidians, we have suggested above an Alpine element, while as to the historical Scythians, what little we do know scarcely indicates that the Scythians reached India in any mass.

The caste system, which in India has acquired a rigidity unparalleled elsewhere, implies the existence of a large number of endogamous groups, the members of which are bound together by a common traditional occupation and belief in a common origin. By this system the whole course of a man's life—how he shall eat, drink, dress, marry and give in marriage—is irrevocably determined by the accident of birth. The

[1] *The People of India* (1908). [2] *The Peoples of Asia* (1925).

political significance of caste is therefore immense, and whatever its defects it does ensure an amazing continuity in tradition and in the arts and crafts, while on the ethnic side it cannot but play an important part in fixing physical type.

The original significance of the word *varna*—" caste "—was doubtless that implied by " colour," as denoting purity of breed. In the *Institutes* of Manu (compiled between the fifth and second centuries B.C.) a separate origin is ascribed to each of the four classes into which the community was divided, which later became the four traditional castes, *viz.* the Brāhman (priestly), Ksatriya (warrior), Vaisya (merchant), and Sūdra (cultivator and menial).

At the present day Risley distinguishes seven different types or varieties of caste. First the tribal, *e.g.* the tribes of Chota Nagpur and the Nagas; secondly the functional or occupational, perhaps the most familiar to Europeans and often regarded as the chief factor in the evolution of caste; the third type is sectarian, *e.g.* the followers of a popular reformer outcast themselves and very soon form a new caste; a series of new castes may be formed by the crossing of one with another, and Risley gives as a fifth type the " national castes," such as the Newars—once the predominant race in Nepal—or the Marāthas. Caste may also be formed by migration, where a group outcasts itself by moving and forms in its new home a new caste, and finally certain castes may have arisen from change of custom as, for example, the Rajput and the Jāt.

If we seek to speak of an Indian temperament we can only say that the old speculative Hinduism, with its mystical systems of religion and philosophy which we call Brahminism, was no doubt introvert, but how far introversion was the preponderant disposition among the upper classes generally, and whether it still plays as important a part in modern Hinduism as it did of old, is another matter, though the history of Buddhism certainly suggests that it may. This system, arising as a protest against the mystical formalism and particularism of Brahminism, although it made headway against Brahminism for centuries (partly no doubt because its sects made no difficulty in accepting, in mild disguise, much of the old mystic philosophy) and numbered millions of converts, yet at the present day is extinct in India. It may be added that caste, with its precise and unalterable determination of every man's position in the social fabric, seems to be just one of those examples of " arrangement " which are so typical of the introvert disposition.

AFRICA

In broad outline, the ethnology of Africa is so much simpler than that of the other continents that, in spite of vast unsurveyed areas and uncharted tribes, it is comparatively easy to write an account of its racial history. It is true that classification, or at least delimitation, has been very largely based on linguistic criteria, for the facts of language are relatively easily determined, and though in themselves no safe guide to race, nevertheless in Africa speech and race do so substantially correspond in regard to the great racial groups that such terms as "Bantu," "Semitic," etc.—

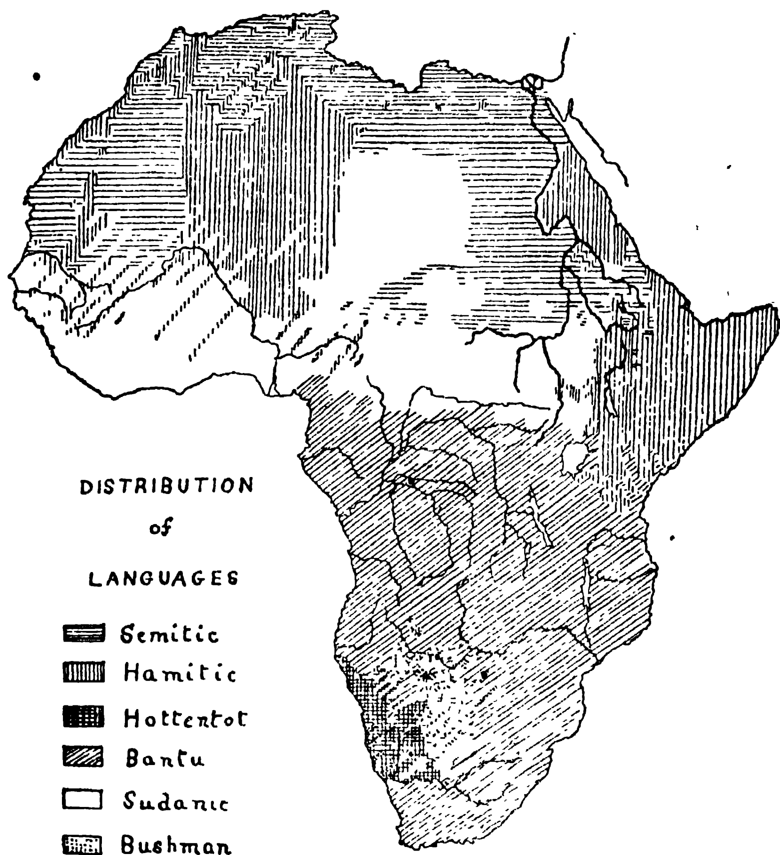


Fig. 6.—LINGUISTIC MAP OF AFRICA

which, strictly speaking, have no more than a linguistic significance—are habitually employed with a high degree of racial accuracy.

The main divisions of mankind in Africa are as follows:—

Bushmen } sometimes known as Khoisan
Hottentots }
Negritos
Negroes
Hamites
Semites

It must, however, be remembered that the Semites—apart from a certain amount of mixture in Abyssinia—have only been in Africa a little more than a thousand years, and their influence has in the main been confined to the country north of the Sahara.

Of these divisions the Hamites, Negroes, and Bushmen are by far the most important.

In considering the movements and mixings that have gone on in Africa, it is well to remember that there are no great mountain ranges to obstruct the free movements of peoples, but deserts in the north (and to a limited extent in the south) with tropical rain forest in the west, though that on the edge of the Abyssinia plateau is hardly sufficiently broad to constitute an obstacle.

Apart from relatively late Semitic influence—whether Phœnician (Carthaginian) and limited, or Arab (Muhammadan) and widely diffused—the history of Africa is in the main the history of the Hamites, with the record of their interactions with the two more primitive African stocks, the Negro and Bushman, whether this influence was exerted by highly civilised Egyptians or by such wilder pastoralists as are represented at the present day by the Beja and the Somali. To emphasise the importance of the Hamites and the part they have played in Africa, it is only necessary to look at a map showing the distribution of languages in Africa at the present day, when it will be seen that Hamitic languages are spoken by peoples spread over perhaps one-fifth of Africa (*see Fig.* 6). The area inhabited by people regarded as Hamitic is even larger, including, as it does, many tribes superficially semiticised through the influence of Islam, and before the Arab expansion Hamitic languages must have been spoken over by far the greater part of the northern half of the continent. It is necessary to realise that the number of immigrant Arabs was never very great, and that the social results of intermarriage and the prestige of the dominant religion, far more than a substitution of Arab for Berber blood, accounts for such arabisation as has taken place.

Ethnologically, then, Africa may be divided into two sections, the northern essentially white or light-skinned, inhabited by Caucasian Hamites and Semites, the southern essentially Negro, with peoples almost everywhere characterised by their dark skin and woolly hair. A line drawn from the mouth of the Senegal River, through Timbuktu to Khartum, thence southwards and westwards to the Abyssinian border at about 12° N., following the Abyssinian border to the Juba River and Indian Ocean, marks out the northern boundary of the Negro with fair precision, but it must be realised that the term Negro includes at least three huge groups, each with its peculiar characteristics. Almost everywhere in this vast area the Negro carries Hamitic blood and has been influenced by Hamitic culture. The true Negro is mainly confined to West Africa, while the rest of negro Africa consists of Negroes hamiticised to a varying extent—on the one hand the Bantu, on the other the Nilotes and half-Hamites.

The Hamites—who, as already stated, belong to the Mediterranean race—are commonly divided into two great branches, eastern and northern, and their cradle-land is generally agreed to be Asiatic, perhaps Southern Arabia or possibly an area farther east, though Sergi suggests the Horn of Africa. There is no doubt that the Hamites and Semites must be regarded as modifications of an original stock, and that their differentiation did not take place so very long ago, evidence for this statement being furnished by the persistence of common cultural traits and linguistic affinities. Physically their relationship is obvious, as also their kinship with the European representatives of the Mediterranean race, though

some anthropologists admit this relationship only for the Northern branch of the Hamites, proposing to distinguish these from the Eastern branch by the term "Libyan."

To the Eastern Hamites belong the ancient and modern Egyptians, the Beja, Berberine (Barabra or Nubians), the Galla, Somali, Danakil, and, though mixed with Semites and Negroes, most Abyssinians.

The Northern Hamites include the Berbers of Tripoli, Tunis and Algeria (often conventionally distinguished as Libyans), the Berbers of Morocco, the Tuareg and Tibu of the Sahara, the Fula of Nigeria, and the extinct Guanche of the Canary Islands.

Apart from a few skeletal remains, referred to the Old Stone Age, the oldest "Africans" of whom we have any organised knowledge are of the great group of Eastern Hamites.[1] These are the pre-dynastic Egyptians (proto-Egyptians, anterior to about 3200 B.C.), whose burials leave no doubt as to their identity with the Beja of the eastern Egyptian desert, to-day the purest representatives of the Hamitic race. This is well brought out by comparing stature and cephalic index of the proto-Egyptians and of two modern Beja tribes, and is of extreme interest, implying as it does a stability of type for a period extending for some 6,000 years.

	C.I.	*Stature*
Beja { Ababda	73·7	64 in
Beja { Beni Amer	74·7	64½ in
Proto-Egyptians (Naqada)	74·9	64 in

Nor in this matter are we limited to physical measurements. We have two notable representations of the proto-Egyptians as they were in proto-dynastic times 5,000 years ago and again in the twelfth dynasty about 2000 B.C. The first of these is the head of an ivory figure (*see Fig.* 7*a*) found at Hierakonopolis. It is only necessary to compare this, with its straight nose, well-modelled lips, and slight beard, with the photograph of the Beni Amer (*see Fig.* 7*b*) to see the likeness. The twelfth dynasty example comes from Meir, where on the west bank of the river, and some 160 miles south of Cairo, is a group of twelfth dynasty tomb-chapels dating to about 2000 B.C. On the walls of one of these there is a wonderful drawing of a Beja herdsman (*see Fig.* 7*c*), undoubtedly one of the most successful examples of racial portraiture of the Ancient Egyptians. The long thin figure and limbs, with broad chest, narrow flanks, and almost retracted abdomen, are no doubt conventional and exaggerated representations of the characteristics of the pastoral desert men as they appeared to the agricultural Egyptians, but there can be no criticism of the splendid naturalism of the lined face, the thin pointed nose and the mop of hair projecting over the forehead, and standing out stiffly over the whole head to the nape of the neck. The beard is the usual chin tuft of the Beja tribes. A glance shows the close resemblance, even to the hairdressing, to the Hadendoa whose head (*see Fig.* 7*d*) is sketched from photographs taken near Port Sudan.

[1] This ignores Mr. Leakey's recent important unpublished discoveries in East Africa; his preliminary announcement indicates that the Upper Palæolithic inhabitants of the Kenya plateau were not Negroes.

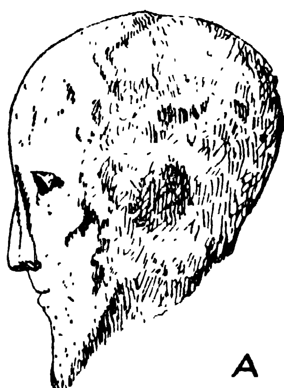








Fig. 7.—PERSISTENCE OF PROTO-EGYPTIAN TYPE IN NILE VALLEY

A. Ivory Head, Hierakonopolis at 3000 B.C. B. Modern Beja (Beni Amer). C. Wall painting (Meir 2000 B.C.). D. Modern Beja.

The Northern Hamites are typically represented by the Berbers, who are skilled agriculturalists and gardeners, while many are pastoralists as well. Their social organisation differs entirely from that of the Arabs, being as essentially democratic and suited to a sedentary life as that of the latter is aristocratic and apt for a nomadic existence, though it must be realised that this typical contrast is not absolute, and that in North Africa there are many sedentary Arabs and some nomad Berbers, the Arabs presenting a diminishing percentage of the population from east to west. The Berbers are good craftsmen, and the silver jewellery of Algeria is characteristic and distinctly beautiful, while their pottery shows an interesting resemblance to that of the proto-Egyptians.

The Arab conquest of Egypt in the years 639 to 641, although important culturally, cannot, owing to the small number of immigrants, have had any great ethnic effect on the population of the Nile Valley. It was the great invasions of the eleventh century, and especially the migration of the Beni Hillal and kindred tribes, that led to the effective arabisation of North Africa and to the dominance of Islam. For in Africa, as elsewhere in Islamic lands, creed counts for more than race, and the name " Arab " is applied to any people professing Islam, however much Negro or other foreign blood may run in their veins, so that, however great its cultural value, the term is of little ethnic significance and often is frankly misleading. Yet in a broad sense, and excluding the Berbers, the term remains of positive value as denoting a vast series of tribes, claiming, even if they have it not, a predominant Caucasian ancestry, boasting a particular historic tradition and religion, and speaking a Semitic language. In this sense the peoples we call Arab contrast with all the other Africans we have discussed in that they exhibit an essentially uniform culture, even if in many instances they can boast but little of the newer immigrant blood to which this culture is attached.

The Arabs of Africa may be divided into three main cultural groups : true nomads (" people of the camel ") ; Baqqara (cattle folk), semi-nomads ; sedentaries. Actually some tribes, such as the Kenana of the Anglo-Egyptian Sudan, include all three classes, and many nomad tribes have sedentary sections, while there may be a limited nomadism, as when a tribe sows its crops in an oasis in the autumn and leads a more or less wandering life until the spring. Tribal organisation is far stronger among the nomads than among the sedentaries, and it is among the former that the purest Arab physical type is found, *e.g.* among the camel-owning Kababish of the Anglo-Egyptian Sudan or the Aulad Ali of Eastern Tripoli. Even here there is considerable variation, largely determined by the wealth of the tribal sections and the consequent amount of black slave blood.

Though the Negro is no doubt one of the oldest stocks in Africa, no Negro skulls of any great age have yet been discovered. The antiquity of the race is, however, indicated by one of the great proto-Egyptian slate palettes, dating from *circa* 3200 B.C., which depicts captives and dead with woolly or frizzly hair and showing the same form of circumcision as is now practised by the Masai and other negroid tribes of Kenya Colony ; moreover, the Archæological Survey of Nubia has brought to light a

burial—with typical Negro hair—dating to the Middle Kingdom (about 2000 B.C.).

The true (West African) Negro, whose physical characters are described on page 445, possesses certain characteristic cultural features. They build gable-roofed huts; their weapons include bows, tapering at each end, with bowstrings of vegetable products, swords and plaited shields, but not clubs or slings; among musical instruments are wooden drums and a peculiar form of guitar—the so-called West African harp; clothing is of bark-cloth and palm-fibre, not of skin; secret societies, masks and wood-carvings of the human figure are characteristic; cattle are absent, the domestic animals being the dog, goat, pig, and hen; cannibalism occurs, and human sacrifice—formerly common—might attain a huge scale, as in Ashanti. On the artistic side, the West African Negro shows a skill in plastic art that is hardly found elsewhere in Negro Africa, the carved ivories, wooden and ivory masks, and bronzes of Benin being specially noteworthy.

As already stated, the great part of Negro Africa is occupied by mixed populations of hamiticised Negroes (though some of the members of the Bantu group carry but little Hamitic blood and show no great signs of Hamitic culture). The origin of these Negro-Hamitic peoples will be understood when it is realised that the incoming pastoral Hamites arrived in a long succession of waves, of which the earliest may have been as remote as the end of the Pluvial period. Better armed than the agricultural Negroes among whom they settled (there was no Bronze Age in Africa, and the Negro, now an excellent iron worker, presumably learnt this art from the Hamites), they would soon assert their superiority over the latter. Gradually a series of peoples combining Negro and Hamitic blood arose; these, superior to the pure Negro, would be regarded with disdain by the next incoming wave of Hamites, and be pushed farther inland to play the part of an invading aristocracy *vis-à-vis* the Negroes on whom they impinged. This process was repeated over a long period of time, the agriculturalists always dominated by the pastoralists and tending to leave their own mode of life in favour of pastoralism or to combine the two. The result of one such series of combinations is to be seen in the Zulu, another in the Baganda, while an even more striking example is afforded by the symbiosis—to use a biological term—of the Bahima and the Bahero. The Bahima, a tall cattle-owning aristocracy with narrow nose and long faces (though they always have Negro hair), are utterly unlike the shorter, broader-faced, Negro Bahero in whose country they live and who normally provide them with grain.

It is not surprising that classification is difficult, and the observer is compelled to fall back on the relatively easily determined facts of language. With this reservation the following may be regarded as the primary divisions :—

(1) The half-Hamites, inhabiting East Africa and East Central Africa from the neighbourhood of Lake Rudolph in Kenya to 5° or 6° S. in Tanganyika Territory.[1]

[1] These are sometimes called Nilo-Hamites, a thoroughly inappropriate term since there is no evidence to suggest that they arose from a mixture of Nilotes and Hamites, nor that they are Hamites living on the Nile south of Khartum.

(2) The Nilotes of the Nile Valley, extending from the Anglo-Egyptian Sudan into Uganda.

(3) The Bantu, a congeries of peoples occupying the southern two-thirds of black Africa, roughly delimited by a line running irregularly from the Rio del Rey to the mouth of the Juba River.

The half-Hamites, as the term implies, carry a considerable amount of Hamitic blood, *i.e.* definitely more than the Bantu and Nilotes. The relative preponderance of the Hamitic side of their ancestry is reflected alike in speech, appearance and culture. They all speak languages of Hamitic type, and although dark-skinned their faces are generally Negroid rather than Negro. Culturally they are predominantly pastoralists, many of their tribes leading the semi-nomadic life which this entails. The Nandi, Masai, Turkana, and Suk are perhaps the best-known tribes of this group.

The second great group of hamiticised Negroes are the Nilotes, a well-defined physical type, speaking Sudanic languages and associated with a particular culture, who occupy the Nile Valley from some 200 miles south of Khartum to Lake Kioga, one group reaching Lake Victoria. The majority of Shilluk—who, with the Dinka, may be taken as the most typical representatives of the Nilotes—are obviously Negroid rather than Negro, while in spite of their dark skins and no doubt preponderantly Negro blood the Nilotes are culturally far more Hamitic than Negro, their predominant pastoralism being reflected (as in the half-Hamites) in the almost religious esteem in which they hold their cattle. Human sacrifice is very rare and cannibalism unknown, in contradistinction to their neighbours on the other side of the Nile-Congo divide. The men for the most part go naked. Psychically the Nilotes show an aloofness and pride of race, with a lack of desire for European clothes or trade objects, which is probably unparalleled elsewhere in Africa.

The Bantu are a congeries of peoples named from and defined by the peculiar type of language they speak, which is generally considered to have originated in the neighbourhood of the Great Lakes. Apart from the nations grouped round the shores of the Great Lakes (Baganda, Bakitara, etc.), where the Hamitic invaders from the north have mingled less completely with the older inhabitants, the infusion of Hamitic blood which differentiates the Bantu from the pure Negro is strongest in the east and south, weakest in the west and north.

The Bantu may be divided into three main groups : Southern Bantu, inhabiting the vast region south of the Zambesi and Kunene Rivers ; Western Bantu, reaching from the Kunene River in the south to the Rio del Rey (separating Southern Nigeria from the Cameroons) in the north and from the Atlantic to the Rift Valley (line of the Great Lakes) in the east ; Eastern Bantu, stretching from Uganda in the north to the Zambesi in the south.

The Southern Bantu comprise the Shona peoples, the Zulu-Xosa (including the so-called " Kaffirs " and the Matebele), the Suto-Chwana (Bechwana, Basuto, etc.), and the Herero-Ovambo ; they are grouped into a very large number of tribes showing great diversity in physical characters.

The area of the Western Bantu includes the true " Heart of Africa,"

the tropical rain forest of the Congo, the home of such little-known beasts as the okapi, and of pygmy hunting tribes with habits and beliefs of which we are almost entirely ignorant, but it also includes (or included) the territory of considerable and highly organised kingdoms, such as the mediæval kingdoms of the Kongo and the Balunda, and in later times the Bushongo Empire, as well as such renowned cannibals as the Fang. The southern limit is vague, the Lunda Empire and Jaga raids, with subsequent encroachment of wandering tribes, having played havoc with tribal organisation.

Of the Eastern Bantu, the Lacustrine tribes, as already mentioned, present a more recent Hamitic element than that which originally gave rise to the Bantu; indeed, among the Banyankole assimilation between the two stocks has scarcely gone beyond the possession of a common language, spoken alike by the intruding Bahima and the indigenous Bahero.

Apart from the Lacustrines the Eastern Bantu include such well-known tribes as the Akamba and Akikuyu, essentially agriculturalists, although cattle are even here regarded as the embodiment of wealth. Among these tribes there is, strictly speaking, no chief, but government is in the hands of a council of elders, with only local authority, a man's position in the community being according to the seniority of his age-grade. The Wachagga on Kilimanjaro share with the Lotuko of the Nile Valley the interesting custom of exhuming the bones of their dead after some months, the skull being then taken to an ancestral shrine or deposited in an earthen jar in the neighbourhood of the village. The Swahili of the east coast are specially important, as their language has become the *lingua franca* of a great part of East Africa.

The Bushman is distinctive in appearance from all other Africans save only the Hottentot, and belongs to a type so ancient that he may well have been in Africa for a period to be measured in tens of thousands of years, while until less than a century ago he was using stone tools of the type that was being made in Europe towards the end of the Old Stone Age. It is generally agreed that the Bushmen reached their present home in South Africa from the north, their ancestors having perhaps occupied the great part of tropical East and East-Central Africa, while the former extension of the race over practically the whole of South Africa is shown by the distribution of its relics—skeletal remains, rock paintings, and even place-names. Apart from isolated offshoots, their present range is restricted to the Kalahari Desert and the northern half of South-West Africa, where alone their original mode of life has been retained.

The Bushmen lead a primitive nomadic life as hunters and food-gatherers, their social organisation and culture being of the most simple. The southern Bushmen are notable for the paintings and engravings which in the past they executed on the walls of caves and rock shelters. The paintings, many of which are of comparatively recent date, are naturalistic studies of high artistic merit, depicting animals, cattle-raids, dances, and magico-religious scenes in which animal-headed human figures are represented. This art seems to have completely died out.

The Bushmen are rapidly becoming extinct. Even before the arrival

of the white man in South Africa they were being forced out of their hunting-grounds by their stronger Bantu and Hottentot neighbours, and the white colonists continued the process of dispossession and destruction, until the ancient owners of the land, unable or unwilling to adapt themselves to their changed environment—to domesticate animals or cultivate the soil—were reduced to a few scattered and dwindling remnants.

There is little doubt that the Hottentots are the result of the mixture of Bushmen and early invading Hamites, with an infusion of Bantu, and it is generally held that the mixed race arose in the north, perhaps near the Great Lakes, and did not reach South Africa until after the Bushmen. The former distribution of the Hottentots comprised practically the whole of the western part of South Africa from the Kunene River in the north to the Cape Peninsula in the south, and extended inland to the Kei River. To-day, though scattered remnants are to be met with over a considerable part of this area, their tribal organisation is only found in a state of preservation in South-West Africa north of the Orange River. Like the Bushmen, whom they dispossessed, they are now a passing people, and only a remnant of their former customs survive. Culturally the outstanding difference between the two races is that the Bushmen are hunters and food collectors only, while the Hottentots are a pastoral people, with herds of long-horned cattle and flocks of fat-tailed sheep ; they also differ from the Bushmen in practising the art of smelting iron, make wooden pots, weave baskets and mats from reeds and rushes, and make skin bags to hold milk and water. Their material culture is, then, superior to that of the Bushmen, but they do not appear ever to have possessed the art of painting and engraving on rock at which the older and more primitive race excelled.

Of the pygmy Negritos of Africa but little is known ; not only are we ignorant of their social organisation, but no one has yet discovered whether they have a language of their own, all recorded vocabularies belonging to the speech of their Negro neighbours. Hunters, trappers and collectors, they are nowadays confined to the thick tropical forests within 6° north and south of the Equator, but folklore and classical tradition point to their having had a much wider distribution a few thousand years ago ; as long ago as the Pyramid Age (*i.e.* in the third millenium B.C.) the Pharaohs were sending south—but certainly not so far south as the Congo Valley—for pygmies to dance before them.

It is not only among the islands of Farther Asia that the Oceanic Mongols have travelled in their clumsy-looking but seaworthy craft; passing westwards, they reached Madagascar sufficiently long ago for an early form of Austronesian (Malayo-Polynesian) to become the standard speech, while the Antimerina, generally called Hova, a group of sixteenth-century immigrants of fairly pure blood (perhaps originating in Java), now form the dominant aristocracy of the island. The greater part of the population is negroid, and it seems natural to suppose that this element is African, but considering that the language of Madagascar

is an early form of Austronesian and the strong currents between Africa and Madagascar, as well as the facts that Madagascar culture is not Bantu, and that the latter are not seamen, there is much in favour of the suggestion that the black element is also from the Far East, *i.e.* consisted of Oceanic Negroids, who are known to be expert seamen. Immigrants from Arabia have certainly played an important part in forming local dynasties, some arriving so early that, as reported, they recognised the patriarchs but not the Prophet.

In the south there has been immigration from India, and in the north European pirates and slavers have left their mark; *e.g.* the man who consolidated the Betsimakara, one of the more important tribes, and provided them with a royal house, was a half-caste.

AMERICA

The Eskimo occupy the Arctic coasts of North America, Greenland, and extreme North-East Asia, and must be regarded as early immigrants of Asiatic type.[1] They are short (st. 62½ in.) dolichocephals (C.I. 72) with broad flat face and prominent cheek-bones; nose narrow, moderately prominent; eyes black and straight, but the epicanthic fold is occasionally present.

The Amerinds (American Indians) occupy the rest of the New World, it being understood that they have for the most part been exterminated in North America, and in the southern half of the continent are largely represented by mixed breeds. The hair is everywhere black, lank and coarse; skin colour yellowish-white to chocolate, usually some tint of brown; stature varies but is generally high; skull generally mesaticephalic, but ranging from low dolichocephaly to high mesaticephaly; face usually broad, with high and laterally prominent cheek-bones; eyes brown, with sometimes a suggestion of Mongolian characters; nose often well developed and straight, even aquiline in some northern stocks.

In spite of variation in appearance between groups, ethnologists are generally agreed that there is an underlying general similarity of type among the peoples of the New World which can only point to an original common parentage. Further, since it is highly improbable on zoological grounds that man originated on the American continent, this must have been peopled either from the east or from the west, and the resemblance to the Mongolian type is so widespread that it seems certain that the homeland of the American Indian was Asia rather than Europe; moreover, while there is no easy access to the New World from Europe, the gap between Asia and North America *via* Behring Straits is only some forty miles.

This seems a simple conclusion. It is in fact so simple, considering the complexity of physical characters and cultures found in the New World, that some little elaboration is really due. Since, however, space forbids

[1] "It seems to be fairly well established that the Eskimo were the result of a migration of a special type into America at presumably a very early date. The most representative appear to be those of the Hudson Bay district which would thus be a secondary area of characterisation" (Haddon: *The Races of Man*).

any general discussion of all the lines of argument, it must suffice to transcribe the conclusions reached by Hrdlička and supported by Wissler :—

" The American natives represent in the main a single stem or strain of people, one homotype ; this stem is identical with that of the yellow-brown races of Asia and Polynesia ; and the main immigration of the Americans has taken place, in the main, at least, gradually and by the north-western route in the earlier part of the recent period, after man had reached a relatively high stage of physical development and multiple secondary differentiations. The immigration, in all probability, was a dribbling and prolonged overflow, likely due to pressure from behind, or want, and a search for better hunting and fishing grounds in the direction where no resistance of man as yet existed. This was followed by multiplications, spread, and numerous minor differentiations of language due to isolation and other natural conditions, and by the development, on the basis of what was transported, of more or less localised American cultures. It is also probable that the western coast of America, within the last 2,000 years, was on more than one occasion reached by small parties of Polynesians, and that the eastern coast was similarly reached by small groups of whites, and that such parties may have locally influenced the culture of the Americans ; but such accretions have nowhere, as far as we know to-day, modified the native population."[1]

It is not possible to state the date at which the ancestors of the American Indian first entered North America—a date some 4000–5000 B.C. is perhaps plausible[2]—but this can be said, that no implements or other evidence of early or middle palæolithic man (using the terms in a Western European sense) have been found in the New World, some of the so-called palæoliths that have been produced from time to time being no more than rejects, or rude or unfinished tools, while the skeletal fragments have not passed the test of skilled examination. There is, in fact, no valid line of argument that when man first migrated into America he was other than neanthropic, or that his stone technique was other than a simple form of stone chipping. But this need not imply very recent or, as sometimes stated, a neolithic immigration ; the variety in language and physical characters in America can only point to a prolonged period of physical differentiation.

Linguistic considerations point in the same direction. All American languages yet studied are morphologically akin ; they all belong to the " polysynthetic " group—that is to say, languages that permit of a whole sentence being included in a single polysyllabic word—not one true example of which is found anywhere in the eastern hemisphere, where the Basque, Caucasus, and Ural-Altaic groups limit incorporation to pronominal and purely relational elements. It is clear that a system so apart from all the conditions found elsewhere must imply a long development

[1] Clark Wissler : *The American Indian* (1922).

[2] At the other extremity of the time scale it has recently been suggested that the more northern tribes of the Athapascan linguistic stock (inhabiting the Mackenzie River area and so nearest to Asia) have reached the New World since the beginning of our era.

and consolidation, and the time is also demanded by the vast number of stock languages prevailing throughout the continent, all differing profoundly in their vocabulary, and in fact with nothing in common except this extraordinary polysynthetic groove in which they are cast. There are probably about seventy-five stock languages in North America, of which fifty-eight occur north of Mexico, indeed it has been stated that there are as many linguistic stocks in America as in the whole of the Old World. Moreover differentiation within a stock is very great, and the dialects usually as mutually unintelligible as, for example, English and German.

All this goes well with the relatively primitive condition of the culture generally accepted as having been that of the immigrants. Even at the time of the Discovery, although there was cereal culture there was no plough, corn was ground with the push quern, but the rotary quern was unknown, while the wheel did not exist in any form, so that pottery was built up by hand or with the aid of a mould, and transport was by human porterage, travois, or sledge; there was no metal working except in Mexico (where copper and even bronze were used to a limited extent), the only exceptions being in the fortunate areas where native copper existed, and even here no more was done than laboriously to break away pieces of metal which were afterwards hammered into shape without the aid of heat.

The physical anthropology of the American peoples has not yet been systematised, and no classification can at present be grounded thereon, even with a linguistic basis. Therefore, as a geographical or cultural grouping has much practical convenience, it is customary to adopt a division into areas of material culture, each possessing distinctive features. The location of food areas laid down the general lines of these cultural groupings, the characteristic of such an area being the tendency to specialise in some one or two foods, and the New World is thus comprehended under eight large food areas (*see Fig.* 8). Thus, in North America the Arctic and Sub-Arctic region is the natural home of the caribou or American reindeer; on the Pacific slope we have the salmon area; to the south, in California, the area of wild nuts and seeds, with the acorn as the most typical food; in the heart of the continent, the bison area; the eastern maize area in the Eastern United States; from the Colorado River through Mexico to the lower part of Chile is the area of intensive agriculture, in which maize is again the leading food; the manioc area comprises the interior of the southern continent (although this latter vast region is too little known for us to be able definitely to characterise the food of the whole area); finally, the lower part of the continent has certain similarities to the caribou area, the chief food animal being the guanaco. Of these eight food areas, three may be grouped as the homes of hunting peoples, three of agriculturalists, one of fishers, and one of gatherers of wild seeds.

With this geographical grouping a cultural grouping is generally combined, that is, a classification of social groups according to their culture traits. Wissler gives fifteen areas, each conceived to be the home of a distinct type of culture spreading from a centre. Groups of tribes are thus located as constituting culture centres, and other tribes as

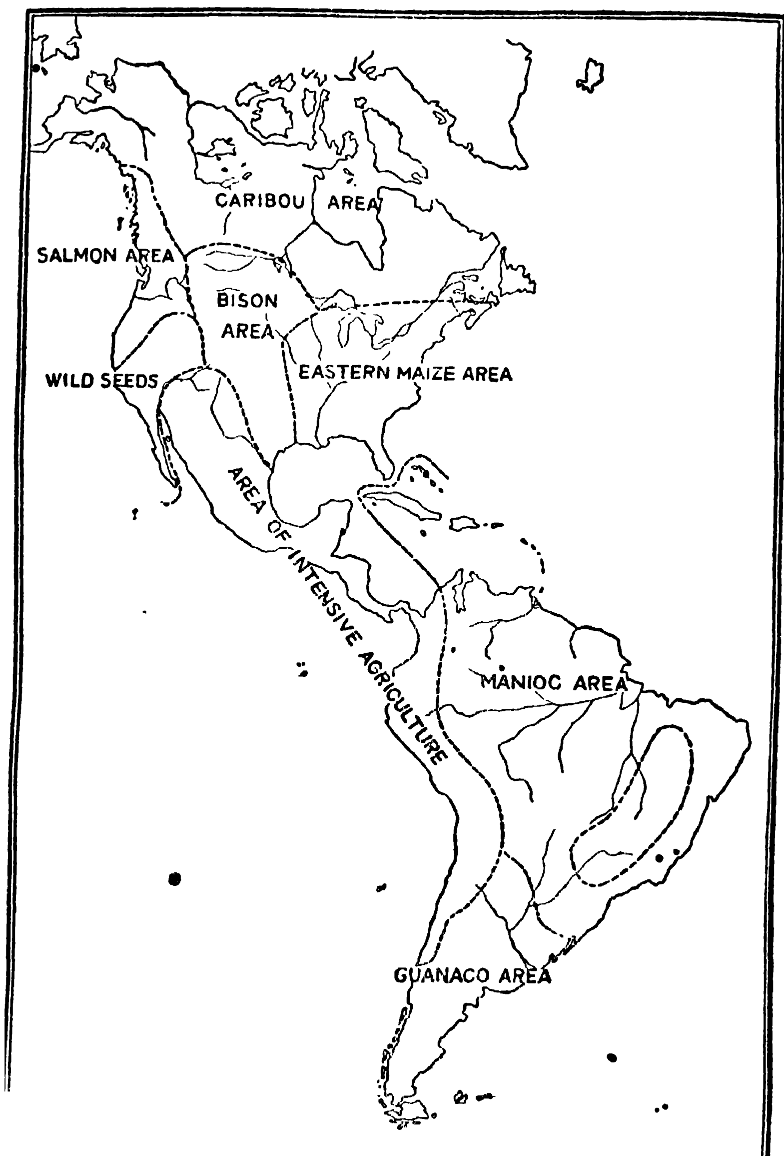


Fig. 8.—FOOD AREAS OF THE NEW WORLD

intermediate or transitional. Space will only permit brief mention of a few of these areas.

The Eskimo area spreads from Greenland to Alaska, and these tribes have developed a highly specialised culture to meet the requirements of the unpromising environment, such archæological researches as have been made tending to show that this culture has remained essentially unchanged for many centuries. Winter sealing, combined with caribou and musk-ox hunting in summer, are the principal occupations. The skin tent is general in summer, and the snow house, as a more or less permanent winter house, prevails east of Point Barrow. Owing to the lack of vegetation in these regions the Eskimo depend almost entirely on animal food : the skins of seals furnish the material for their tents and clothing, the flesh is almost their only food, and the blubber the indispensable fuel during the long winter, when they live in solid snow houses, each occupied by two families. Each settlement has a headman, but his authority is very limited and there is no obligation to obey him. The textile industry is absent except for a little basket-making ; implements and weapons are in the main of ivory, bone, slate or stone. Pottery is unknown. The long Arctic winters provide the Eskimo with leisure to develop the art of carving, especially in ivory, to a high degree of perfection.

It would be consistent to give some such summary as the above for each of the eight remaining cultural areas generally recognised in Canada and the United States,[1] but a suggestion of the results has already been given on page 476, where the characteristic foods that have done so much to shape the culture of each area have been cited. It may, however, be mentioned that in the valley of the Mississippi (the south-eastern culture area) there is archæological evidence of a much more advanced culture than is found there at the present day, for this is the region of great mounds and earthworks, once thought to be of enormous antiquity, and the work of a vanished race, but which later research has shown to be almost certainly constructed by the historical Indians, tribes of the Algonquian, Iroquian, Siouan, and Caddoan stocks. Archæological evidence also points to the continuity of the type of culture represented by the present-day Pueblo Indians, centred in the upper Rio Grande Valley and extending into Mexico (the south-western culture area). The Pueblo culture takes its name from the towns or villages of stone or adobe (sun-baked clay), and exhibits traits not found elsewhere in Canada or the United States, *e.g.* the art of masonry, main dependence upon maize, the loom or upward weaving, the use of a grinding-stone, and the domestication of the turkey. There is evidence of connection between the Pueblo area and the Aztec of southern Mexico, though no architectural evidence of any continuous chain of culture between the two areas exists. The Pueblo Indians were accustomed to ornament ceremonial objects of shell and bone with a mosaic incrustation of turquoise and lignite, an art practised on a far larger scale by the Aztec, and, as

[1] For these areas see Keane : *Man, Past and Present* (1920) and Wissler : *The American Indian* (1922).

there are important turquoise deposits in New Mexico but none in Southern Mexico, it is likely that the Aztec obtained their supplies, probably by indirect trade, from the Pueblo area. The marvellous examples in the British Museum represent the acme of this turquoise incrustation, and are generally admitted to have been sent to Europe by Cortez or his companions.

The peoples of Mexico and Central America may be regarded as constituting the (tenth) Nahua culture area. Here the interest centres chiefly on the two great ethnic groups—Nahuatlan and Huaxtecan—whose relations were so closely interwoven that they can hardly be considered separately. At the time of the Spanish conquest there was one culture from Rio Grande to Lake Nicaragua, typical representatives of which were the Aztec of Mexico City—a branch of the Nahuatlan family—though the Zapote and others were almost equally typical. (The Zapote language is still spoken by a few natives.) Centuries earlier the culture centred round the Huaxtecan Maya in Honduras (later in Yucatan), who have left behind them the most impressive ruins in the New World. The Early Maya alone among the aborigines of America had developed a hieroglyphic script—though other tribes had advanced pictographic art—and their culture is an extraordinary example of artistic and technical development among a people ignorant of bronze and iron. Stelæ have been found dated from about 300 B.C., at which time the population must have attained a relatively high degree of civilisation, including an advanced architecture, a calendar system, and astronomy, while legendary chronology takes us back another three thousand years. It should be noted that the later Maya worked both copper and bronze. Maya building comprised monoliths, temples, and " stepped " pyramids, but magnificent as these buildings were, they show that the Maya were ignorant of three important principles—the use of mortar, the bonding of corners, and the true arch. Sculpture was mainly in relief and was highly skilful; perfect profiles were portrayed, and even three-quarter figures in correct perspective. The art of pottery was highly developed, and vessels were painted in rich designs. Maya religious beliefs were portrayed in the symbolic and ceremonial nature of their art, the rain god being the deity most frequently represented.

The reason for the desertion by the Maya of their age-long settlements remains a mystery, but it is certain that when Cortez passed through the country these wonderful sites had long been swallowed up by jungle, and the Spaniards found the Maya no longer in cities but living in independent tribal groups. At the present day primitive and loosely organised groups are found in this area, speaking Maya languages but with no knowledge of their calendar system or writing. Maya intellectual culture, being exclusive to the priestly caste, either passed to the Aztec or into oblivion.

Before the collapse of the Old Empire, Maya civilisation had spread to the Mexican Valley, where it was adopted by the Toltec, immigrants from the north. The Toltec were followed by a series of invading tribes (Nahuatl-speaking) culminating in the arrival of the Aztec—skin-clad nomads, practising a desultory agriculture and ignorant of weaving and other arts. It was not until 150 years before Cortez that the Aztec became independent, their rapid rise to dominance over the other tribes of the

valley being probably due to their introduction of the bow, together with a genius for political organisation. Their rule was based on a peculiar system of ceremonial war—in which the taking of prisoners for sacrificial purposes was the main object—and of trade guilds, many of which represented submerged tribal groups. Their culture was based on that of the Maya, from whom they borrowed much, including their calendar and deities, and these Maya gods, for the most part of a relatively mild type like the Maya themselves, became in the Aztec pantheon bloodthirsty demons demanding countless victims. Religious festivals were celebrated in accordance with the calendar, and human sacrifice was on an almost incredible scale; besides the annual sacrifice of a young man to the Creator god, there were the gruesome ceremonies in honour of the fertility god, involving the wearing by the participants of the skins of the victims, flayed after their hearts had been torn out on the sacrificial stone.

In South America five great cultural areas may be recognised, two of which, the Chibcha and the Inca, are particularly interesting on account of the high civilisation attained by some of their constituent peoples. We may pause here to note that, in general, the southern populations of the continent present more violent contrasts than those in the north; the wild tribes touch a profounder depth of savagery, while the civilised peoples attain a higher degree of excellence in the arts of engineering, architecture, and political organisation. As in Mexico many of the Nahuatlan tribes remained savages, so in Colombia the semi-civilised Muscayans were surrounded by numerous kindred tribes who were real savages, wearing no clothes and practising cannibalism; cannibalism seems to have been everywhere more rife in the south than in the north, where it survived only as a ceremonial rite.

There is generally a close connection between the surviving peoples of the Isthmus and Colombia, where we come to the most northerly of the great linguistic families of the Andes, the Chibcha-speaking peoples, an agricultural folk with a highly developed irrigation system, a sun cult, no stone buildings or copper, but with great skill in gold work (formerly the centre of the art for the New World). At the time of the discovery the Muysca Empire, the most powerful of the Chibcha group, was coterminous southward with that of the famous Inca of Peru—the dominant nation of the Quichuan race—though the two civilisations seem to have been quite distinct.

Like the Aztec, the Inca built their empire on the ruins of an earlier civilisation, of which the megalithic remains at Tiahuanaco (at the southern end of Lake Titicaca, now 13,000 ft. above sea level) are the most important monument. This pre-Inca civilisation appears to have flourished at about the same period as that of the earliest dated Maya monuments, though as the Peruvians, unlike the Maya, had evolved no form of script, even of a pictographic nature, we have no means of dating their architectural remains. (The only form of record used by the Inca was the quipu, an elaborate system of knotted cords.) The ruins of Tiahuanaco are megalithic, with a celebrated monolithic gateway; the masonry, apart from the great size of the blocks, is almost unique in that the stones are polygonal and often carved with re-entrant angles, each

stone being cut to fit its immediate neighbour. The pottery is also of excellent technique, and that found at Truxillo (" proto-Chimu ") is some of the most remarkable ever produced by a people ignorant of the wheel, the modelled vases in human form giving us minute details of the dress and physical characters of the population. Metals, both gold and copper (the latter often a form of bronze), were known and worked to a far greater extent than among the Maya.

Many centuries elapsed between the fall of this megalithic civilisation and the rise of the Inca towards the end of the eleventh century A.D. Tradition agrees that the Inca, with the sun as their tribal god, entered Peru from the south, probably from the Bolivian highlands. At the time of discovery eleven Inca had ruled in Peru, by which time their empire stretched from Quito in Ecuador to the River Maule in Chile, comprising more than 35° of latitude, and they had assumed the position of a ruling caste rather than a dominant tribe. The system of control of this enormous area was a rigid combination of theocracy and state socialism, based on belief in the ruling Inca as a god on earth; agricultural labour and military service were compulsory for all, and no member of the tributary population might move from his village or marry outside his district. The Inca were wonderful road builders, and though their masonry lacked the force of the older civilisation their buildings, of rectangular stone cut to size and accurately fitting without mortar, are perhaps technically the most perfect ever constructed by a people ignorant of iron. There was complicated ceremonial worship, and human sacrifice took place, but not apparently, as among the Aztecs, on a large scale. The Quichua dialect is still spoken over this area.

The great basin of the Amazon is one of the world's most typical tropical areas, but in spite of the savagery of many of its tribes there is almost everywhere some native agriculture—manioc (the tapioca plant) being the staple crop—though the tribes are not dependent on it as are those of the intensive agricultural area, and the responsibility for cultivation is usually assigned to the women.

The countless aborigines of the Amazon and Orinoco basins are dominated by four linguistic stocks, the Arawak and Carib in the north-west, the Tupi and Tapuya in the south-east. Of these the first pair are the most widely distributed and occupy the whole of the West Indies, as well as the greater part of Venezuela, Guiana, and Northern Brazil. Physically the Arawak and Carib are very similar, and the ethnic division is admittedly on linguistic grounds only. The Tapuya (Botocudo, Ges, etc.) are the aborigines of Eastern Brazil, and include many primitive forest tribes. Both in culture and physical characters they perhaps represent an early type of immigrant, possibly allied to the type known as Lagoa Santa, to which some ethnologists have attached perhaps undue importance. All their implements are of wood, they do not work stone, and they have no tradition of migration; they are pure nomads, roaming the woods in a nude state in search of roots and berries, and are notorious cannibals. The Tupi formerly occupied an immense area, estimated at one quarter of the southern continent, and extending into Peru. They were an aggressive people, addicted to cannibalism. Most tribes practised agriculture to some extent.

The Highlands of Bolivia, Patagonia, and the lower half of Chile comprise the so-called Guanaco area, the Araucanian, Puelchean, and Tsonekan (Tehuelche) being among the most important stocks. Here the domestication of the llama and alpaca provides the only example of pastoralism in the New World; the Spanish colonists introduced horses and cattle, and, like the Indians of the North American plains, the natives of this area quickly developed an intense horse culture. These people are said facially and mentally more to resemble Europeans. To the Araucanian group belong the folk commonly called Pampaen (Pampas Indians), now mainly represented by the half-breed Gauchos.

The Patagonians (Tsonecca), of giant stature for South America (st. 68–72 in., C.I. 85), are of uncertain origin, and it has been suggested that their original home was amongst the Bororo of Matto Grosso in Brazil, whom they closely resemble. The Bororo are said to be an exceptionally tall, round-headed people (st. 68½, C.I. 81.5).

The native life of the most important islands of the Antilles was almost completely stamped out by the Spanish conquerors. So far as we know, the pre-Columbian population was first pure Arawak, but later overrun by Carib.

The Yahgan, the aborigines of Fuegia, are a sea-shore people, formerly cannibals, and with a culture so primitive that it may fairly be described as of bone and shell.

OCEANIA

Oceania is broadly taken to indicate Australia and the island groups of the Pacific, but does not include the Aleutian Islands in the North Pacific nor even the islands of Indonesia. Its natural geographical units are Polynesia, Micronesia, Melanesia (including New Guinea), Australia, and Tasmania, while the peoples that have gone to populate it are Negritos (in New Guinea), Polynesians, Micronesians, Melanesians, and Papuans with their archaic branch, the Tasmanians and Pre-Dravidians (Australians). Of these peoples the pygmy Negritos, the Tasmanians, and the Australians are by far the most primitive.

We know little about the pygmies of New Guinea, except that they are no longer a food-gathering, hunting folk, but practise much the same agriculture as their taller neighbours. As already stated, the typical Papuan is short, dark, and long-headed, though mesaticephalic and even brachycephalic "islands" occur, *e.g.* in the southern part of British New Guinea. We cannot account for these variations; presumably they are the result of miscegenation. Be this as it may, it seems that a somewhat variable Papuan stock at one time existed over the whole of Melanesia. Thus (with Negrito admixture) we may account for the short stature of some Papuan hillmen, for the extreme dolichocephaly of some Fijian tribes, and the extinct Tasmanian with his dolicho-mesaticephaly and medium stature.[1]

The Australians, whose physical characters are described on p. 445, represent an old and unusually homogeneous stock, indicating, in spite of probable foreign cultural influences, no effective immigration into the continent since their arrival.

We may feel confident that these three primitive types reached the Pacific by the Malay Peninsula and Indonesian Islands. The presence of pygmies in the Philippines makes this clear for the Negritos. We have no direct evidence for the Papuans, but for the Australians our knowledge is more precise; not only has a fossil "proto-Australian" skull been dug up at Talgai in Queensland, but two skulls in fossil or semi-fossil condition, clearly Australoid in character, have been found at Wadjak in Java.

All this seems relatively simple, probably because we are dealing with migrations of high antiquity. The migrations of Polynesians are much more recent and more difficult to understand, while of the past history of the Micronesians and their history we know practically nothing.

The position when the Polynesians entered the Pacific was roughly as follows. The islands that are now Polynesian were uninhabited, or some may have carried a primitive "black" population. The Polynesians, starting from Indonesia, moved eastwards through Melanesia to their future homes in the Eastern Pacific, so that even now a line drawn from New Zealand through Fiji to Hawaii cuts the Pacific into eastern Polynesian and western Melanesian-Papuan areas. We can even indicate a portion of the route taken by the Polynesians in passing through Melanesia, basing our conclusions on small island populations showing Polynesian characters in the midst of Melanesians. Thus the Polynesians passed along the north coast of Netherlands New Guinea, sailing westwards round the Bismarck Archipelago (leaving traces at Abgarris or Fead Island), then south-east, north of the Solomons (colony on Ontong Java), and so to Tikopia, the most important of these colonies. There is, or was, a colony on Uea (Wallis Island), but this is generally taken to be a backwash from Polynesia.

So much for the pre-history. Traditionally, and probably in actual fact, the Samoan group formed a rallying-ground for the migrants, who may be supposed to have left Indonesia some 2,000 years ago, and Savaii—one of the Samoan islands, originally Savaiki—is a name which in one form or another is found, often as the homeland, accompanying the Polynesians all over the Pacific.

For the sake of simplicity we have spoken of the Polynesians as though they were one people, but it is certain that there was a number of greater waves, each carrying, according to Rivers, its contribution to the culture that we call Polynesian. We can indeed differentiate physically two main stocks, varying in stature and cephalic index, which have been well described by Haddon.[1] The first stock, represented by the more European-looking Maori, is tall and of slender build, with relatively long head and face, open eyes, narrow and high nose; the lips are thin, hair abundant on face and body, and the skin generally light. The second stock is slightly brachycephalic, and may be regarded as carrying "proto-Malay" blood; this type is shorter than the first, with coarser features, the skin is darker

[1] *Op. cit.*

and hair less profuse. We may add that a type with Melanesian characteristics also occurs in New Zealand, indicative either of pre-Maori Melanesian settlers or, more probably, a high proportion of Melanesian blood in particular groups of colonising Polynesians.

We are now in a position to understand the physical characters of the Melanesians, as apart from Papuans. We may, if we like, lay stress on the tendency to variation in the Papuan stock (very obvious to any observer in one hundred miles of New Guinea coast), but in any case we can best explain the modified physical characteristics of many Melanesians—including the sometimes lighter skin, the smoother, less craggy bones, the less consistently frizzly hair—by a slow soakage of Polynesian blood which has spread slowly from community to community during the last two millennia or more.

Of Micronesia we know very little, but in essence the story is the same, with presumably a far greater amount of Indonesian blood. There is much variability from group to group : in the east the skin is light, the hair wavy or straight, in the west there is a considerable number of darker-skinned people with almost frizzly hair.

THE ACHIEVEMENTS OF ARCHÆOLOGY

By

E. A. GARDNER

SYNOPSIS

Archæology has many branches, some of which overlap with other studies such as history and anthropology. The earliest products of human handiwork are the chipped flints of the palæolithic age; these show progressive development, and consequently afford valuable evidence as to period. The most remarkable remains of this age are the cave paintings of France and Spain. In the neolithic or polished stone age are found the first examples of pottery, which continues through all subsequent ages as a useful criterion of date. Civilisation and art reached a very high level in Egypt and Mesopotamia at least before 3500 B.C. The study of classical archæology has been carried on by travellers and excavators of all nations, especially in Greece and Asia Minor. Many Greek statues have been found in Italy, but they were mostly restored and placed in private galleries. Since the end of the eighteenth century a more historical study has prevailed and museums have been founded in all civilised countries. The history of vase painting, from the Cretan and Mycenæan age through the classical period in Greece, has also been studied in detail, and the subjects represented have supplied information as to religion, mythology and daily life. Gems, coins and inscriptions have contributed greatly to our knowledge. In central and western Europe the sites known as Hallstatt and La Tène have yielded characteristic examples of pottery and metal work.

Recent discoveries have carried back to a remoter age our knowledge of Egypt and Mesopotamia, and an interesting episode of Egyptian art has been found at Tell-el-Amarna. With new methods, especially the help of air survey, there are prospects of still further discoveries in the future.

THE ACHIEVEMENTS OF ARCHÆOLOGY

DEFINITION

The province of Archæology is by no means easy to define, and different authorities use the word in distinct senses. It should mean " the science of ancient things " ; but any attempt at delimitation between it and other studies must depend partly on its subject, partly on its aims and objects, and partly on its methods. Perhaps the clearest way to realise these is to compare it with other kindred studies, such as history, anthropology, ethnology and the history of art, all of which overlap it to a greater or less extent.

The materials of historical study are for the most part literary, depending upon written documents, at least in the case of classical and modern time ; while archæology deals more with the visible and tangible remains of earlier ages. But this distinction holds only with certain branches of both history and archæology, especially with regard to such nations as have left behind them a literary record. In some cases, however, notably in the cases of Egypt and Mesopotamia, there are extensive historical documents, engraved on stone or impressed on clay, which had to be deciphered and interpreted before they could convey any useful information. And the deciphering of inscriptions is generally regarded as a branch of archæology. In cases such as these, the archæologist has to supply the material out of which the historian must construct a record of events and of the life of the people. But in the cases of Egypt and Mesopotamia, no less than in those of Greece and Rome, it is the function of archæology to supplement the literary and historical evidence by its own more special contribution to our knowledge of the past, whether illustrated by the remains of its activities, or expressed by means of its arts and handicrafts.

Beyond all this there is a rapidly widening region of human knowledge which is sometimes especially assigned to archæology, though shared to some extent by anthropology. This is what is commonly known as prehistoric archæology—the only kind recognised by some of the narrower definitions of the study. Archæology certainly has here a freer scope, since its discoveries and theories cannot be controlled and checked by the collateral evidence of other branches of knowledge—except, in some cases, geology. It is evident that a study which covers so wide an area must differ greatly in its aims and its methods, and cannot well be treated with any degree of generalisation. Its various branches may best be considered separately ; and for this purpose the scheme of division drawn up under expert advice by the University of London is convenient, though not of course exhaustive. For the purpose of academic study, archæology is in this scheme classified into eight sections :—

1. Prehistoric. 2. Western European. 3. Egyptian. 4. Assyrian. 5. Greek and Roman. 6. Early Christian and Mediæval. 7. Renaissance. 8. Oriental.

If Mesopotamian be substituted for Assyrian, and it be understood that Oriental is intended to include China, India, and Persia, this list may be regarded as suggesting the main lines of archæological studies.

The present Article deals mainly with what has been discovered about the ancient peoples who have influenced our civilisation.

PREHISTORIC

The ultimate limit of archæology may be said to be the first appearance of man upon the earth. In its earlier stages this study may be held

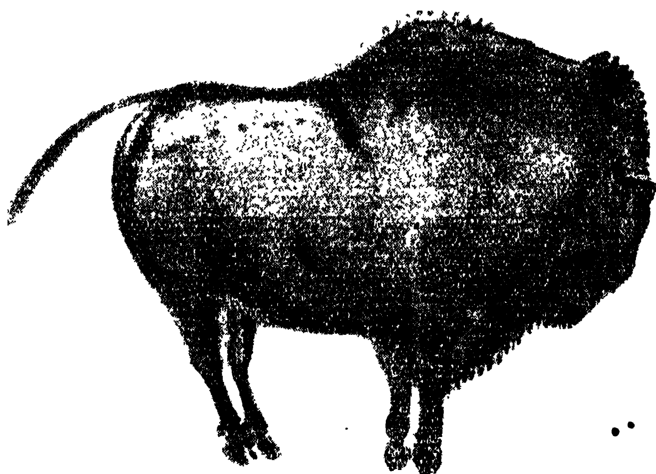


Fig. 1.—PAINTING IN ALTAMIRA CAVERN. MAGDALENIAN PERIOD

to belong rather to the sphere of geology and anthropology. Prehistoric archæology begins with the first traces of human agency or handicraft; and for a long period the series of chipped flints which have been found in all parts of the world serve to those who have the requisite knowledge as an index and guide. They have been carefully classified, and various styles and successions have been noted of bolder and finer, until we come to the exquisitely skilful handiwork in finely shaped and chipped flints, which are characteristic of the later phases of the early flint or palæolithic age. Throughout these periods there is no historical or social background to be traced except the succession of glacial eras traced by the geologist. The names given to the various styles for convenience in classification are mostly due to accidents of modern discovery, being taken from villages in the south of France or Spain where the first characteristic specimens were noted. For the earlier palæolithic age nothing

beside worked flints has been found, but for the later periods, known by the names of Solutrian and Magdalenian, there is evidence of artistic activity of the most remarkable quality, showing a sense of form and power of expression far beyond anything that appeared probable or possible at so early a date (*see Fig.* 1). These discoveries, when they were first made about fifty years ago, were received at first with scepticism; but they have since been amply confirmed by the discovery and publication of numerous other similar representations in caves and rock shelters in the same region, and also of somewhat similar finds in various parts of the world, such as the drawings of the Bushmen in South Africa, though these latter may be very much later in date.

The discovery of these products of the palæolithic age is the most remarkable attainment of prehistoric archæology, and gives us a most vivid notion of the life and artistic power of man at a time when nothing but chipped flints had before been known. The representations are mainly those of animals, including many now extinct, such as the mammoth, and others, such as the reindeer, long unknown in this region. There are drawings, reliefs, and modelled figures in relief or in the round. The most primitive, probably, are mere outlines traced by the finger, or by a bone or flint, upon a more or less hard ground. The forms are correct, and the action often spirited. The natural colours are often imitated by pigments, and not only local colour but light and shade are often indicated. These early painters and sculptors succeeded in producing work of a far higher artistic quality than anything known to us before the highly developed arts of Mesopotamia, Egypt, and Greece.

It has been disputed whether drawing and painting, or modelling and carving in relief and in the round, came first. The actual reproduction of the shape of animals or other natural objects may appear the more primitive, since anything like relief or drawing requires a certain abstraction or convention in the translation of an object from three dimensions to two. On the other hand, drawing on a flat surface is technically the easier process and requires less complicated tools or appliances. The finest work in relief or in the round is done in hard materials, such as mammoth ivory or reindeer horn; this must have been worked by tools made of flint, and is often astonishingly life-like. Both in painting and in carving we find mammoths, boars, reindeer, bisons, a primitive kind of horse, and other animals. Human figures rarely appear, and then with no approach to the feeling for natural form found in the case of other animals (*see Fig.* 2).

NEOLITHIC POTTERY

A remarkable thing about this artistic ability of the men of the later palæolithic age is its complete disappearance in the succeeding period, without any apparent survival. This may be due to a glacial era or other cataclysmic disturbance, or to other circumstances which we cannot trace. The makers of the smoothly polished flint implements of the later age commonly called neolithic did indeed produce some representations of events, with human and other figures; but these are little more than symbolic in character, with no attempt at a realistic imitation of natural forms. On the other hand, our knowledge of the arts and handicrafts and

even of the civilisation of the neolithic age has advanced rapidly in recent years, and has received contributions from many parts of the world. Smoothly polished flints replace the chipped flints of earlier times, though the art of chipping flints did not become extinct, and even survives in many places to the present day. But it no longer provides the only, or even the chief criterion for estimating the relative dates of various deposits. The art of pottery arises from the discovery that clay can be moulded into various shapes and then hardened by fire so as to hold water or other materials such as grain, and so as to serve for storage, cooking and drinking. From this time on it supplies an immense variety of potsherds, for while earthen pots are easily broken, the fragments of these remain practically indestructible through all ages. Consequently, on almost any site that has been occupied since neolithic times, sherds of ancient pottery have been found. And these, by the patient study of experts and careful observation, have come to be recognised as an indication

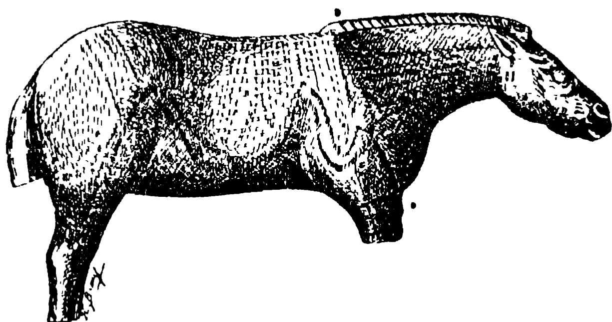


Fig. 2.—HORSE CARVED IN IVORY, FOUND IN THE GROTTE DES ESPELUGUES AT LOURDES. EARLY MAGDALENIAN PERIOD

of the age and attainments of the people who made them. Some characteristics are common to many local varieties of early pottery, others vary considerably from place to place. For example, the earliest pottery is usually hand-moulded, and has little ornament beyond what can be made with the fingers. Other examples are highly polished, as if with a bone or a flint; others again, in slightly more advanced times, have patterns incised in the wet clay with a sharp instrument. These patterns are mostly either of a wavy or geometrical style. They are followed by similar patterns in pigment, either dark on a light ground or light on a dark ground (*see Fig.* 3). It is impossible here to give either a general or detailed description of the forms of ornamentation of this early pottery. All we can notice at present is its wide distribution, not only around the Mediterranean basin and northern Europe, but also in Asia, in Mesopotamia and Persia, and even in India, and south Russia and the Ukraine. What is more remarkable still is that pottery with similar decoration is found in both North and South America. In New Mexico, for instance, it is still made at the present day. It is not, of course, to be supposed that it spread from a few centres, or that similar pottery in different regions is contemporary.



Fig. 3.—PRE-SUMERIAN PAINTED POTTERY FROM AL'UBAID
After drawings by the late F. G. Newton

It is often a difficult problem in archæology to decide how far similarities such as these are to be assigned to the direct or indirect influence of one race or region upon another, how far the true explanation may be that the human eye and hand tend under similar conditions to produce independently similar results. This is really more a question for psychology than for archæology.

BRONZE AGE

Unlike the work of the palæolithic age, that of the neolithic seems to continue almost without a break until it is succeeded by the great advances that mark the progress of early civilisation. Remains of it are often found in the lower strata of sites which have yielded the richest discoveries belonging to later ages, such as Troy or Cnossus. The great advance is mainly associated with the discovery and use of metals, copper first and probably gold, and then bronze, leading up to the great civilisation of the bronze age in Mesopotamia and in Egypt. Recent years have seen

remarkable discoveries in both regions, reaching back to the fourth millennium B.C. or even earlier. And perhaps the most astonishing thing of all is that the artistic products of these early ages show nothing of the tentative or experimental character of a primitive art, but a masterly and technical skill in the treatment of metal and other materials which implies a long previous training and development. Yet it remains a mystery whence the origin of these two national arts was derived ; much may have been developed from experimental work in perishable materials. But these two, interacting but slightly on each other, may be traced in continuous succession almost to the present day, that of Mesopotamia through Babylonian and Assyrian to Hittite, Persian and Parthian, and many branches of Oriental art ; that of Egypt through Greece and Rome to the Renaissance and modern European art.

In the case of both Egypt and Mesopotamia the historian is dependent to some extent on the archæologist, since the evidence he has to deal with is mostly preserved in inscriptions. In both alike we find from very early times a system of writing which implies a long development from pictographic script before any of the documents that have come down to us ; and from the earliest examples to historical times these have persisted in various forms as a record, in the case of Mesopotamia continuing as cuneiform through its use to express Sumerian, Semitic, Assyrian and Persian languages.

CLASSICAL; HISTORY OF STUDY

The aims and attainments of classical archæology may conveniently be considered in the order in which various discoveries have been made and various methods have been employed. Though a systematic and scientific study of archæology has mainly been developed during the last half-century, earlier travellers had already done much to spread in the west of Europe a knowledge of the remains of architecture and sculpture that were still to be seen in Greece, and had even, in some cases, transported them to places where they were more accessible. The English traveller Wheler, for example, described Athens as it was in 1676 ; two years earlier the French artist Jacques Carrey had made an invaluable series of sketches of the sculpture of the Parthenon, and thus preserved for us a record of much that was destroyed in the disastrous explosion of 1678. But it remained for Stuart, in 1750, to make a series of accurate architectural drawings of Athenian buildings, and so to enable those who had not travelled to appreciate what Greek architecture was like in its finest examples. In 1800 Lord Elgin obtained leave to remove some of the sculpture from Athens, and consequently the Elgin Marbles found their way to the British Museum. So far little had been taken that did not show on the surface, at least in Greece. In Italy many excavations had been made in order to find works of sculpture, but these were isolated statues, many of them brought from Greece, which had been buried by chance in Italian soil. With the nineteenth century began the practice of exploring the sites of temples and other Greek buildings for the sake of the sculptures that once ornamented them.

This was the case at Ægina and at Bassæ near Phigalia. In both cases the excavators carried off the marbles that they found and sold them in

the one case to Munich, in the other to London. But at the same time the architect Cockerell, who was one of the excavators, made a careful study and publication of the architecture of the two temples; and he and Wilkins, and other architects, introduced a revival of classical and especially of Greek architecture in the buildings they designed. Towards the middle of the century English explorers and excavators brought to England many fine sculptures from the Greek cities of Asia Minor—the Nereid monument (*see Fig.* 4), the Harpy monument, and other tombs from Xanthus in Lycia were brought by Fellows, with the assistance of a British man-of-war detailed for the purpose; and similar help was given to Newton, who held the post of British Consul while excavating at Cnidus and at Halicarnassus for the Mausoleum, and to Wood during his excavation of the temple at Ephesus.

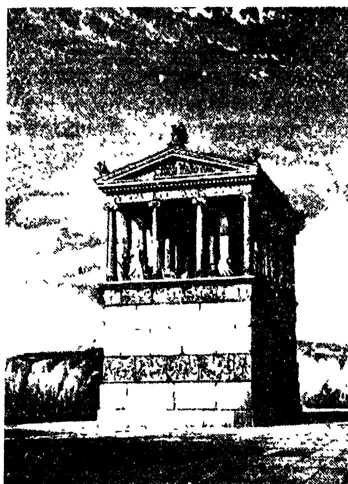


Fig. 4.—NEREID MONUMENT

STUDY IN GREECE

Meanwhile, in 1846, Penrose made those exact studies and measurements of the Parthenon and other buildings which revealed for the first time the subtlety and precision which are characteristic of Greek architecture at its best. After the foundation of the Greek kingdom in 1830, it was no longer possible or desirable for antiquities found in Greece to go out of the country; but they were collected and cared for by the Greeks and by foreign archæologists, and Athens came to be the chief centre for the study of Hellenic art. Foreign archæological schools were founded there, the French in 1844, the German, American, British, and others at various intervals. All alike devoted themselves to exploration and excavation in Greek lands, and to the study of the buildings, sculptures and other works of art, inscriptions, and other antiquities preserved in the museums at Athens and elsewhere. The Archæological Institute, which was in a

sense the parent of them all, had been founded in Rome in 1829 as an international undertaking, but as the German element in it became predominant, other nations founded schools of their own in Rome as well as



Fig. 5.—GOLD MASK FROM MYCENÆ

Athens. None could take anything out of the country; but they vied with one another in friendly rivalry, contributing each his own share to the discovery and study of the history, art, and archæology of Greece.

The limits of our knowledge of ancient Greece did not, before the middle of the nineteenth century, reach much beyond strictly historic times. The Homeric poems indeed seemed to belong to a previous age; but the stories they told were often thought of merely as myths or fairy-tales, and the poems themselves were regarded by many as a compilation of no very primitive date. The great discovery which astounded the learned world, and opened up the beginning of a new vista of ancient history and life, was not the work of a professed archæologist or scholar, but of a man who as a boy had cherished an enthusiasm which led him to believe in the literal truth of the Homeric poems, and an aspiration to put his beliefs to the test of excavation when he should be able to do so. Schliemann cherished this belief all through a busy life, during which he accumulated the necessary funds, and then settled in Athens to put his theories to the proof. Already, in 1869, he had published his belief that Troy would be found on the side of Hissarlik and that the graves of Agamemnon and his companions were to be sought, according to the statement made by Pausanias in the second century A.D., within the walls of the citadel of Mycenæ. It is a matter of common knowledge how brilliantly his theories were confirmed by his discoveries at Troy. His excavations there, which mainly took place between 1870 and 1880, and which had in their later part the skilled co-operation of Professor Dörpfeld, laid bare not only the city described in the Iliad, but many earlier and later cities on the same site; of these the sixth in order of succession is shown by its pottery and other indications to be contemporary with the lords of Mycenæ, and has the finest stone walls still standing to a great height.

At Mycenæ, in 1876, Schliemann found, within the citadel, a sacred circle, within which were graves containing masses of gold ornaments, weapons, gold masks (*see Fig.* 5) and many other things such as had never been found in Greece before.

It was almost to be expected that such a find would at first cause a certain amount of scepticism. Schliemann's own claim, that he had found the actual bodies of Agamemnon and his companions, seemed to be justified by his prediction that they would be found. But the most absurd and impossible explanations were suggested at first, such as that the treasure had been left there by a barbarian invader in late Greek or mediæval times. It was not long, however, before other discoveries, less numerous and magnificent, but similar in artistic character, came to confirm, or modify, Schliemann's theories. The origin of this art remained long a puzzle, for no foreign art in the least resembling it was known, or was likely to have influenced it. It was indeed suggested that the origin might be sought in Crete; but until Crete could be satisfactorily explored, this remained a mere conjecture. And so long as Crete remained subject to the Turks, it was impracticable to obtain suitable conditions for excavating. In the meanwhile Sir Arthur Evans had already secured a hold upon the site of the palace at Cnossus; and as soon as systematic excavations could be carried out, Crete at once took its place as one of the chief early centres of Mediterranean civilisation and art. It soon became obvious that a people of very advanced civilisation and a high degree of



artistic skill had been living in Crete many centuries before it sent out to the mainland of Greece those offshoots which had established themselves at Mycenæ and elsewhere, and which produced the remarkable work of which the graves found by Schliemann are representative. The connection with Crete also involved connection with Egypt at various periods, and so provided a system of chronology which affords a firm basis for Greece also. Throughout, not only gold and silver work but also carved gems and pottery can be systematically arranged and dated, thus providing a most useful criterion for date and influence.

EXCAVATIONS IN GREECE: OLYMPIA AND DELOS

The half-century which saw the discovery of Mycenæan and Cretan art was also marked by great and systematic excavation upon various historic sites in Greece. First among these comes the excavation of Olympia by the Germans. The site had long been known, and the French had carried off some fragments of the sculpture of the temple in 1829. The project of a complete excavation of Olympia had for some time been cherished by the Germans, and in 1876 a skilled staff of excavators was appointed. Though hardly any buildings remained standing on the site, it was hoped that the excavation would make it possible to realise, at least in imagination, what the home of one of the great national festivals of Greece was like in the time of its glory. This expectation was fully justified. The Altis, or sacred enclosure, could be traced, with its surrounding walls; in the middle of it was the great temple of Zeus, its massive columns lying as they had been thrown down by an earthquake, the sculptures that once had ornamented it scattered about or built into later walls. Two other temples, the Heræum, the earliest of Greek Doric buildings, and a later temple to the mother of the gods, were placed just below the Hill of Cronos, which dominates the Altis to the north; and many other buildings were found, as described in Pausanias' guidebook; among the most interesting are the treasuries of the various Greek cities, some of them with rich terra-cotta ornamentation and groups of early sculpture. It is now possible to wander round the Altis and its surroundings, the porticoes to receive visitors, the gymnasium where the athletes were trained, the stadium where the foot races took place, even the grooves in which runners had to place their feet at the start. All the sculpture and other perishable material has been housed in a museum on the spot. These include the magnificent pediments and metopes from the temple of Zeus, and among individual statues found were the Hermes of Praxiteles, discovered in the very place in the Heræum where Pausanias saw it at his visit, and the graceful Victory of Pæonius, set upon her lofty pedestal.

About the same time as the Germans began the excavation at Olympia, the French School at Athens undertook the exploration of another early centre of Greek religion in the island of Delos, the birthplace and sacred island of Apollo. The conditions here were very different. In contrast to the alluvial plain of the Altis, the rocky island of Delos had little soil beside the stony débris from numerous buildings, and was, as it is now, quite deserted. The funds available were much more limited, and

therefore the excavators at first had to content themselves with a careful seeking out and recording of all ancient walls and buildings, without any attempt at a complete clearance of the site. This has, however, been carried out by degrees as opportunity offered, with the result that it is now possible to trace the foundations not only of temples, treasuries and porticoes, but also of many public buildings and private houses of later Greek date, as well as precincts of foreign gods and other indications of the various activities of Delos in Roman times. There are also very

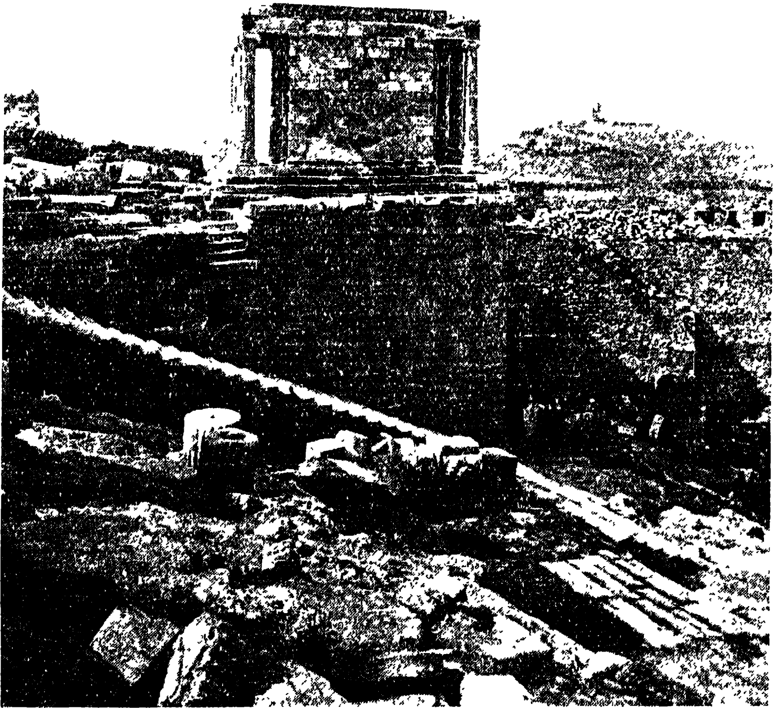


Fig. 6.—TEMPLE OF NIKE (VICTORY), ATHENS

numerous and very long inscriptions, which give much information as to the history and administration of the island at various periods, and as to the contents and property of the temple. The sculptures found in Delos are of high interest. But though there is a small museum in Delos to house the pottery and other antiquities that have been found there, the sculpture has mostly been transferred to the National Museum at Athens.

ATHENIAN ACROPOLIS

Meanwhile the Acropolis at Athens, the most interesting and the most promising site in Greece, had remained practically in the same state since the foundation of the Greek kingdom. One of the first things that were

done under the new administration was to clear away all the walls and houses of Turkish construction; but for the most part the bare rock was visible, so that excavation did not at once suggest itself. The Parthenon, the Erechtheum, and the Propylæa remained standing, but few other indications remained. One of the first undertakings of Ross, the German archæologist who was in charge of antiquities under King Otho, was the re-erection of the little temple of Victory (*see Fig.* 6) just outside the Propylæa, out of the original blocks, columns and reliefs that had been built into a Turkish bastion shortly before the bombardment of the Acropolis which led to the explosion in the Parthenon. The Frankish tower, which had been built on to the Propylæa when that building was



Fig. 7.—FEMALE STATUE, ATHENS

used as the palace of the Dukes of Athens, and which formed a conspicuous landmark in mediæval views of Athens, was demolished in 1864, thus leaving clear the plan of the south-west wing of the Propylæa.

The great scheme for a complete excavation of the Acropolis down to the living rock was carried out in 1886 and the following years in the most complete manner. After some trial-pits had been sunk to ascertain the depth and nature of the soil, the whole was dug out systematically, beginning from the Propylæa, and working along to the north of the Erechtheum, round the eastern end to the great accumulation of soil between the basis on which the Parthenon stands and the south wall of the Acropolis; in the central area, between the Parthenon and the Erechtheum, there were found the foundations of the early temple of Athena and the peristyle built around it by Pisistratus. The chief finds of early Attic sculpture had been buried in the space between the Erechtheum and the north wall of the Acropolis (*see Fig.* 7). They had evidently been thrown

down by the Persian invaders, and carefully placed by the Athenians in the position where they were found in the course of terracing up the ground within the new walls. As a result they give us a remarkable series which illustrates the sculpture known or made in Athens in the period just before 480 B.C. A more complicated problem is offered by the stratified mass of débris found to the south of the Parthenon. For the great basis on which the Parthenon stands was constructed to carry an earlier temple, and the lower parts of the terraced earth which adjoins it must have been placed in position some time before the Persian Wars. It was in this region that most of the fragments of sculptural groups and architectural remains of Piraic limestone have been found. They are evidently of earlier style than the marble statues that have been found elsewhere on the Acropolis.

As a result of these excavations the history of the Acropolis, which formerly was hardly known before the fifth century B.C., can now be traced to remote antiquity. In many places it is possible still to see the walls built of large blocks of Acropolis rock, which remind us of those of Mycenæ and Tiryns, and must belong to the same age; they follow the natural contours of the rock, and are in great part hidden beneath the walls of the fifth century; and numerous fragments of pottery of Mycenæan style have been found in the lower strata of the terraced soil. Open pits have been left in convenient places, so that it is still possible to see parts of these earlier walls. Amidst the foundations of the early temple of Athena it is still possible to trace the remains of the well-built house of Erechtheus which it replaced. And to this early time also belong the postern and staircase that are now visible, but were hidden in classical times. Another approach is through a natural cleft in the rock, which may be identified as the means by which the Persians made their way into the Acropolis to take the defenders in the rear, and by which also, in all probability, the maidens called the Arrhephori conveyed to the lower town certain sacred objects which they were forbidden to see. Moreover, the sculptures and buildings of which the remains have been found enable us to picture to ourselves the Acropolis as it was before the Persian Wars, and to contrast its quaint brilliance with the sober dignity of the Periclean age. Thus the Acropolis and its excavation offer us a striking example of how much can be gained by systematic excavation on a site that does not at first seem to offer many opportunities for further discoveries.

ELEUSIS

Two other sites excavated by the Greeks offer the most interesting information as to the rites and religious beliefs with which they were especially associated; these are Eleusis and Epidaurus. The Eleusinian mysteries had always been a puzzle to scholars; for though there is plenty of evidence from literature as to the external accompaniments of the mysteries, what actually took place at their celebration remained very obscure. It might be hoped that excavation upon the site would throw light upon this matter. But tentative excavations on a small scale caused more confusion than they removed; for various subterranean passages were found which, it was suggested, might have something to do with sacred apparitions and scenic effects. But a complete excavation of the sacred precinct has shown

that such passages, if they existed, served no other purpose than that of drainage. On the other hand, the discovery of the whole plan of the sacred edifice in which the mysteries were performed has proved most illuminating. The great hall was reconstructed several times, once probably in the time of Pisistratus, once in the Periclean age, and more than once in Roman times; but in every case the same essential form was preserved—a square hall surrounded on all sides by tiers of seats, cut in the rock at the back, and built up at the sides (*see Fig.* 8). This hall was entered by six doors, through one of which a procession coming along the sacred way from Athens would enter; and its roof was supported by rows of columns at right angles to one another, and spread evenly over the whole space. It is evident that the initiated who attended the ceremonies were placed upon the tiers of seats all round the hall, and that the space within was devoted to the hierophant and torch-bearer and other priests and officials.



Fig. 8.—HALL AT ELEUSIS

It is obvious that in such a building no continuous or concentrated attention of the spectators could be fixed upon one point, for the columns would obscure the view of a large number of them at any time. It seems to follow that what is sometimes called the sacred drama was rather of the nature of a pageant, which, winding as it would among the lines of columns, would be most impressive. There was also a large rock-cut terrace at the back, which may perhaps have been assigned to those who had not yet been admitted to the full privilege of initiation, but were only in the state of novitiate. Of course these conditions do not offer us any information as to what actually took place in the hall. But the more thoughtful of ancient writers, both Greek and Roman, speak with the utmost respect of the mysteries and their permanent effect upon the character of the initiated in this life as well as their prospects in the next. They were prepared, by processions, sacrifices, wandering in the dark, and fasting, for the sights and sounds that were put before them, and were doubtless profoundly influenced.

EPIDAURUS

At Epidaurus, we learn much of another phase of Greek religion, and of the miraculous cures attributed to Asclepius. This site has been

thoroughly cleared, and it is now possible to see the whole plan of the sacred precinct, its temples and altar, the theatre (*see Fig.* 9) and stadium provided for those who visited the shrine.

A characteristic feature is a portico in two stories, which we know from inscriptions to be called the Abaton, in which the patients who came to consult the god passed the night. There is also a beautifully finished little circular building called the Thymele (place of sacrifice) or Tholos. Its outer columns were of the simple and dignified Doric order and those inside were of the richly decorated Corinthian style. It was designed by the younger Polyclitus, who was also architect of the theatre, according to Pausanias the most beautiful in Greece. A most interesting series of documents, inscribed on marble slabs, gives a record of the cures attributed to the god. It was evidently compiled by the priests from the votive tablets set up to commemorate the various cures. The usual formula states that a patient came to Epidaurus to consult the god, slept in the Abaton, and

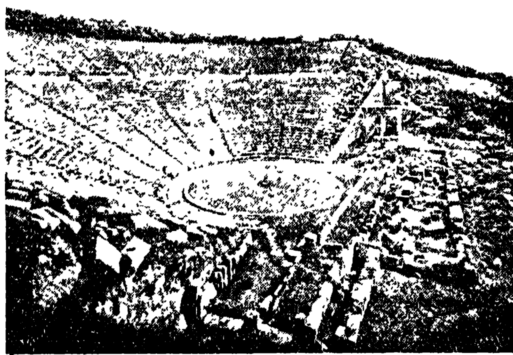


Fig. 9.—THEATRE AT EPIDAURUS

went out whole the next morning. These documents have been much discussed from the medical point of view. Some are clearly apocryphal ; but others record cases which may well be explained as genuine examples of faith-healing, and possibly in some instances of surgical operation. It is interesting to compare both the custom and the cures with what still takes place at the festival of the Annunciation at Tenos, where people gather together from all parts of the Ægæan, where sick or injured people are brought to sleep in the crypt of the church, and where some miraculous cures are still believed to be effected. At Epidaurus other means seem to have been used in later times, when regular medical prescriptions and regimen were adopted ; and the Emperor Antoninus Pius built a hospital in which cases were received for medical treatment ; but there is no evidence that the priests at Epidaurus had a hereditary practice like those of Cos. At Epidaurus some sculptures were found, among them the statues placed in and above the gables of the temple, which we know from inscriptions to have been provided by Timotheus, who was one of the

sculptors employed on the Mausoleum; and there was a copy of the gold and ivory statue of Asclepius, made by Thrasymedes of Paros. It is instructive to compare the remains of the Hieron of Epidaurus with those of the Asclepieum at Athens, situated close to the theatre of Dionysus on the south slope of the Acropolis. Here, on a terrace probably chosen for its sheltered and sunny position, a precinct was arranged beside a primitive healing spring. This was probably done during the Peloponnesian War in 420 B.C. in imitation of the Asclepieum at Epidaurus. It contains most of the features which have been mentioned—a temple, an altar, a pit of sacrifice, and porticoes in which the patients could sleep; and these are of particular interest, because it was to this very shrine that the blind



Fig. 10.—VIEW OF DELPHI

god Plutus was taken by his attendants in Aristophanes' play of that name. And the description of what happened recalls what we are told by the inscriptions about the cures at Epidaurus, the god himself or his priest moving about among the patients, accompanied by the sacred snakes and dogs which also contributed to the effecting of the cures.

DELPHI

Delphi had for many years been regarded as the most promising site in Greece not yet excavated; the chief difficulty in this case lay in the fact that the modern village of Castri was built all over the site of the temple and its precinct. Various tentative explorations were made at intervals, but with little result, except to show that extensive remains existed

beneath the modern houses. The project of complete excavation was at last taken up in 1892, and the first operation was the building of a new village on a position nearer the sea, and the expropriation of the villagers, leaving the site of Delphi free for systematic exploration. The sacred precinct, bounded on each side by walls, is built in terraces high up on the rocky slope of Parnassus. The sacred way, which enters it at the lower eastern corner, takes a zigzag course from terrace to terrace, and beside it, in its lower stretches, are the treasuries of the various cities, as at Olympia and Delos. Some of these—those of Sicyon, Siphnos, and Athens, were decorated with sculptured metopes and friezes. Below the temple there was found a colossal sphinx, dedicated by the Naxians and set up on a high column, and two statues by an early Argive artist, representing Cleobis and Biton, whose story is told by Herodotus. Of the temple itself only the foundations remain (*see Fig.* 10) ; close above it was found the fine statue in bronze of a charioteer (*see Fig.* 11), dedicated as a memorial of his victories by a prince of Syracuse. A group of athlete statues includes a portrait of the Pancratiast Agias, a contemporary marble replica of a bronze original by Lysippus. In the upper part of the precinct, in the east corner, was once the Lesche, or club, of the Cnidians, with its famous paintings by Polygnotus ; only the foundations of this have been found. The theatre in the western corner is so well preserved that it was recently used for the performance of Greek plays. High above it is the Delphic stadium, with its seats in many places well preserved. It is now possible to trace the actual pavement of the sacred way, to identify the position of the various buildings and statues described by Pausanias, and to realise the impressiveness of the site in its wonderful position and numerous monuments. A large number of inscriptions have been found and carefully edited, among them the famous Hymn to Apollo, with musical notation added.

OTHER GREEK SITES

In addition to the complete clearance of such extensive and representative sites as have been mentioned, there have been in Greece many excavations on a smaller scale which have contributed their quota to the advance of the knowledge of Greek archæology. Mention may be made of some of the more important of them. The French have dug at Mantinea, where they found a plan of a circular town laid out in the fourth century B.C., and, in a church, some fine Praxitelean reliefs of Apollo, Marsyas, and the Muses, as mentioned by Pausanias. At Tegea they excavated the temple of Athena Alea, built by Scopas, and found some of the sculptures with which he decorated the temple ; these have supplied valuable evidence as to his style. The British School has excavated the theatre at Megalopolis, the largest in Greece, and has discovered a remarkable and unique building associated with it, the Thersilion or Parliament house of the Ten Thousand, as the meeting place of the Arcadian confederation was called. It was a pillared hall, in some ways resembling that at Eleusis ; but differing in that it sloped up from the centre to all sides, and had its columns arranged in radial lines, so that as few as possible of those present had their view of the speaker obscured. The British School has also excavated on prehistoric sites among the islands,



Fig. 11.—CHARIOTEER FROM DELPHI

at Phylakopi in Melos, a port for the export of obsidian, where the walls and houses of an early town and a great mass of pottery were found, and at the early settlement of Palækastro, at the eastern end of Crete. But the chief activity of the British School in recent years has been devoted to Sparta, above all at the site of the temple of Artemis Orthia. It was at the altar of this shrine that the Spartan youths were scourged until their blood ran down upon it, as a test of endurance. A Roman amphitheatre had been built on the site in later times, but underneath it were found successive early temples, and in the precinct there was found a stratified accumulation of pottery, carvings, lead figurines and other small objects which were observed and recorded with the utmost care, and have consequently provided chronological data for the successive periods of early Spartan art; in particular it has been proved that the ware commonly known before as Cyrenaic was, at least in its earlier phases, of Spartan origin.

The American School excavated the Argive Heræum and found traces of various buildings and a great mass of early pottery, especially proto-Corinthian, and other antiquities, including some of the sculptures from the temple. But the chief enterprise of the Americans has in recent years been at Corinth, where great masses of earth had to be moved. It is now possible to see finely laid out streets and porticoes of Roman date, and also the fountain Pirene, which has had various new architectural fronts at different times. Close beside it is a subterranean fountain house, in which the bronze lion's head from which the water poured is still in position. Here also great quantities of early vase fragments have been found and placed in the local museum.

An example of later Greek sculpture is the colossal group of figures of Demeter and Despœna seated on a throne, and Artemis and the Titan Anytus standing beside them, which was found by the Greek excavators at Lycosura in Arcadia. Pausanias, who describes the group, says it was made by Damophon of Messene. The date of this sculptor was much disputed; but the data of excavation and collateral finds show that he lived in the second century B.C. The group is an attempt to get back to the grand style of the age of Phidias, but there is something artificial about its style and composition such as might be expected at this period.

SITES OUTSIDE GREECE

All these excavations in Greece have been undertaken disinterestedly, for the increase of our knowledge and appreciation of ancient Greece and to add to the artistic treasures of the world. For nothing found upon Greek soil is allowed by the law of antiquities to go out of Greece. All that the excavator retains for himself is the right of publication, and all valuable antiquities are preserved in the museums of Athens or other important sites such as Olympia and Delphi. Elsewhere, until recent years, the law of antiquities was for the most part less drastic, and it was possible for the excavator to carry off all or most of what he found. Thus the collection of early Greek vases from Daphnæ and Naucratis in Egypt has been placed in the British Museum, as have some discoveries from Rhodes and Cyprus. The great Greek cities of Asia Minor have also offered a field for extensive and thorough excavation, though in recent years the Turkish

law of antiquities has been assimilated to that of neighbouring countries, and all the important works of art discovered have been transported to Constantinople. The Germans, however, in 1878, obtained leave to excavate the site of Pergamon, and to carry their discoveries to Berlin. The topography of the town was completely recovered. Its lofty Acropolis contained, at the top, the palace of the kings of Pergamon, the temple of Athena, the great library, the rival of that at Alexandria, and the upper market-place with the great altar. On the slope of the hill was a large theatre; further down, a gymnasium and many other buildings; and in the topmost terrace there was later added a temple of Trajan. The architecture of all these was studied and published, and has enabled a reconstruction of the whole to be drawn, showing it to have been in all probability the most magnificent group of buildings in the ancient world. But the most brilliant discovery of all was the sculptural frieze of the great

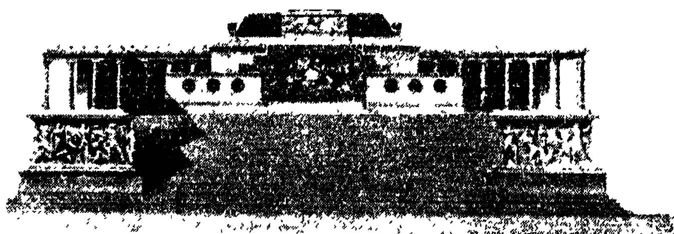


Fig. 12.—GREAT ALTAR AT PERGAMON

altar, which had been demolished and built into later walls of fortification. The altar itself was about 100 feet square, and the frieze surrounded it on all four sides, except for a staircase which led to the top, where the actual altar of sacrifice was placed. The subject of the frieze, which was over seven feet high, was the battle of gods and giants. Nearly two-thirds of this magnificent composition was recovered and sent to Berlin, where a reconstruction of the whole has been made in a special museum (*see Fig.* 12).

Excavations have been made on the sites of several of the great Greek cities in Asia Minor. At Priene the whole plan of the town has been recovered, with its central market-place and senate-house, its temple of Athena, its theatre, and its blocks of private houses which give a clear notion of the character of the dwelling-houses of the Hellenistic age. Excavations have also been made at Ephesus—mainly in the Roman market-place and library, of which a fine architectural front has been found and restored in Berlin—at Miletus and its temple, at Branchidæ, at Sardis by the Americans, and on other town sites. But the conditions for work in this region are not favourable at present, though there are still many sites which would well repay excavation.

One of the most remarkable discoveries made in a region then subject to Turkey was the series of marble sarcophagi found in a subterranean tomb at Sidon in Phœnicia. These were carefully transported by the Turkish authorities, and are now the chief ornament of the museum at Constantinople. It appears that the reigning princes of Sidon had for nearly two centuries, from 500 to 300 B.C., the habit of employing Greek artists to make their marble coffins. The earliest of these with sculptural decoration is called the tomb of the Satrap, from a dignified bearded figure who appears on it more than once in scenes of banquet, battle, and hunting. The style resembles the delicate and refined Ionic work of the early

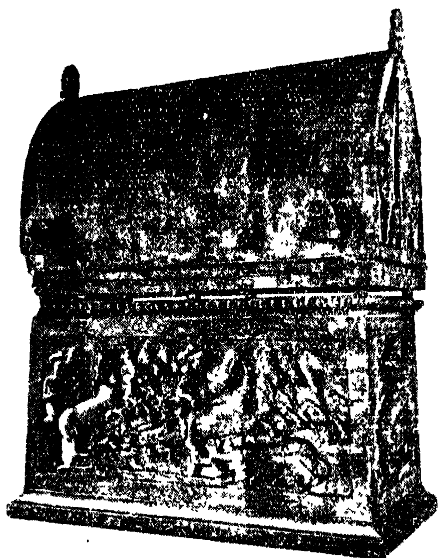


Fig. 13.—LYCIAN SARCOPHAGUS FROM SIDON

years of the fifth century B.C. The second is known as the Lycian from its shape, which has the ogival roof, like a Gothic arch, common in Lycian tombs (*see Fig.* 13). This is in many ways the finest of all the series; its style closely resembles that of the Parthenon sculptures, with which it must be approximately contemporary; it represents hunting scenes in which both Greek youths and Amazons are taking part, and struggles between centaurs, or Cæneus and centaurs, on the shorter sides; sphinxes with outspread wings fill the curved triangles of the roof. The whole is most excellently sculptured and almost perfect in preservation. The third tomb is known as that of the Mourning Women, and is in the form of a miniature Ionic temple; its columns do not stand free, but project from the wall, and between them is a series of women in attitudes

of grief or melancholy. These richly draped figures, in various and harmonious attitudes, remind us of the figures which frequently appear upon Attic tombstones, as a record of the affection of the living for the dead. It has been suggested that such a tomb would be most appropriate for a King of Sidon in the fourth century, who is said to have been strongly Philhellene, and to have had Greek ladies in his harem. The largest and most imposing of these sarcophagi from Sidon is that which is commonly called that of Alexander, because he appears twice in its sculptured scenes, once in a hunting group where he is defending an Oriental rider from a lion, and once in a battle scene. The Greeks, or rather Macedonians, and the Orientals who appear on these reliefs are strongly differentiated, the first a hardy race of soldiers, the others with delicate and sensitive features and expressions. The remarkable preservation of the colour of these sculptures gives quite a new notion of their life-like effect, especially in the pupil and iris of the eyes. It has been conjectured that this is the tomb of a prince of Sidon who was set up and supported by Alexander, and that the scenes of battle and hunting refer to exploits which they had shared. The work may well be of the school of Lysippus.

GREEK STATUES IN ITALY

So far we have been mainly concerned with the discovery of works of art upon Greek soil. In the case of these, we usually have the great advantage that we know where, and often by whom, they were originally set up. But they often have survived merely by chance, and in any case they represent but a minute fraction of what existed in ancient times. It is difficult for us to realise the immense number of statues that once existed on such sites as Olympia, Delphi, or the Acropolis at Athens. The first cause of their transference or loss was the appreciation of the Roman conquerors, who carried off great numbers to adorn their triumphs or to decorate public buildings or private houses in Rome. In 187 B.C. M. Fulvius Nobilior is said to have carried in his triumph 785 bronze and 230 marble statues from Ambracia, where they had probably been collected from other sites by Pyrrhus And Nero is said to have carried off 500 bronze statues from Delphi, though there were apparently plenty left in the time of Pausanias. The plunder went on from time to time, most of the statues being carried off to Rome or later to Constantinople. It is recorded that in the sixth century A.D. there were in Rome as many as 3,890 bronze statues; and of this total only about ten have been recovered. These statues were some of them works of the great period and of the great masters of Greek sculpture; but their identity must often have been lost in the transference. In addition to these there must have been a great number of copies of Greek masterpieces, or imitations, such as were made for the Roman market by Greek artists of the Roman period; and these existed not only in Rome and Italy, but in all parts of the Roman Empire. So far the danger to Greek statues came mainly from the high esteem in which they were held throughout the civilised world. But with the inroads of barbarians and the general failure of appreciation of classical art, especially when the value of the material of which a statue was made counted for more than its artistic quality, the fact that calls for

explanation is not how many statues disappeared, but how so many came to survive. Gold and ivory, as in the colossal statues of Phidias and Polyclitus, had little chance of escaping the plunderers; bronze was melted down for coinage and other purposes; and marble was either burnt for lime, as is attested by the lime-kilns found in almost all ancient sites, or broken up and built into walls or other structures. In this last case the statue may be reconstructed, but usually in a mutilated state. Only a few, owing to accident or particular conditions, have always remained visible. Notable examples are the Wolf of the Capitol at Rome, and the statue of Marcus Aurelius, because, it is said, it was mistaken for the Christian Emperor Constantine; the architectural sculpture from some temples has also survived in some instances, but usually, as is the case with the Parthenon, in a much damaged state. Most, however, of the classical sculpture we now possess has at some time or other been buried in the ground. We have already noticed the instances in which it has been dug up in Greek soil. But a large proportion of the statues in our museums have been found in Italy. Some had been purposely buried to preserve them in some time of stress, like the bronze boxer in the Terme Museum or the Aphrodite of Melos. Many were buried in the débris of the buildings they once adorned. Some were wrecked in vessels proceeding to Italy with the spoils of Greece, like the cargo of ships discovered by divers off Cerigotto and Cape Artemisium, the athlete and the colossal Zeus (or Poseidon) which are now among the chief treasures of the National Museum at Athens. The beautiful Apollo in the Terme Museum at Rome had fallen into the Tiber, and was found when embankment operations were in progress. The recovery of all these buried statues was at first the result of accident. But with the new appreciation of classical art which came in at the Renaissance, ancient statues were eagerly sought for in places where they were likely to be found, especially where there had been palaces or villas in Roman Imperial times; the richest and most famous was the Villa of Hadrian at Tivoli, where the Emperor had gathered together representative works of all ages and styles. The Popes and the Roman nobles vied with one another in searching for antique statues, or acquiring them to decorate their palaces and villas. They were required mainly as ornaments and not as the subjects for serious study. Broken or damaged statues were unsuitable for this purpose; and they were usually handed over to restorers, who replaced what was missing according to their own fancy. Some of the greatest sculptors of the time, including Michel Angelo himself, were employed upon this work. Some of them, with the help of other replicas or the evidence of other monuments, or from a sympathetic understanding of the subjects, produced work which followed very closely what the original must have been. But others were less conscientious, or less gifted, and often used the mutilated remains of an antique statue merely as material to work into a purely fanciful design of their own. One instance of such a statue now in the Louvre may illustrate the result. It is described in the catalogue as follows:

"Youthful Dionysus, nude, his left arm resting on a thyrsus, offers, with his lowered right hand, a bunch of grapes to a panther seated at his feet.

"(Modern—the head of Dionysus, part of his hair, right fore-arm and

bow, left fore-arm and thyrsus, a part of right thigh, both legs and feet, the panther and the plinth.) "

In another case it is recorded that " only a portion of the torso is antique " ; and in the case of a much restored group " the figures are only put together by the caprice of the restorer." Such examples could easily be multiplied. Another practice common among restorers was to piece together portions of different statues, sometimes with successful effect, sometimes with very incongruous results. The commonest example of this is where statues which have lost their heads have had them replaced by other heads whether antique or modern—a state of things often very difficult to detect at first glance, yet very misleading to the student.

This practice of restoration was almost universal until the end of the eighteenth century. The last conspicuous example is offered by the pedimental sculptures from Ægina, which, when they had been removed to Munich, were restored by Thorwaldsen with so great skill that it is difficult without reference to the records of discovery to tell what is ancient and what is modern, the restorer and his assistant have so skilfully imitated not merely the style but the actual weathering of the original marbles. It is evident how much such restoration falsifies the evidence and misleads the student. And, since the restoration is in marble, all fractures had to be cut smooth to fit on the new pieces, and consequently, when further fragments were found in the excavations of 1900, it was impossible to fit them into the places where they belonged. When the Elgin Marbles were brought to London, the Italian sculptor Canova was requested to undertake their restoration. But fortunately he refused, and deprecated any attempt to restore such marvellous works. He thereby not only conferred a great benefit upon posterity, but set an example which has ever since affected the policy of all the authorities of the chief museums. These are some exceptions that " prove the rule," but the restored legs of the Hermes of Praxiteles and of the Agias of Lysippus are not satisfactory, and we may remember the storm of protest, chiefly from artists, which arose when it was proposed to restore the nose of the Demeter of Cnidus. There is not, indeed, the same objection to a restoration in plaster as if it is carried out in marble ; for in this case the surface of the original may be preserved, and the addition can at any time be removed. Perhaps the best solution in the case of masterpieces is to place a restored plaster cast beside the original, for the benefit of those whose imagination does not suffice to enable them to appreciate a statue of which portions are missing.

This change of view as to restoration is partly due to the different view of the study and appreciation of classical sculpture which came in about the beginning, and developed more strongly towards the middle and end, of the nineteenth century. Before that time, those who studied or wrote about classical sculpture were to a great extent occupied with finding meanings and identifications, often of a fanciful character ; and these sometimes imposed themselves on the restorer. Examples are the giving the name Cincinnatus to the Hermes binding his sandal, or Arria and Pætus to the Gaul who has slain his wife and is stabbing himself. Even the dying Gaul, though admirably criticised by Byron, is called by him the Gladiator, and so given a misleading association. The tendency even went so far

as to recognise the Emperor Hadrian and Sabina in the Cecrops and his daughter of the Parthenon pediment.

GROWTH OF MUSEUMS; HISTORICAL STUDY

The collections of sculpture which had come into existence in Italy and elsewhere were more for the enjoyment of the owner and his friends than for the education of students; the foundation of museums as distinct from private galleries was at once a cause and an indication of a different point of view. The great galleries of the Vatican might, indeed, be regarded as a national rather than a private possession. The Louvre was made into a museum, mainly of sculpture, in 1793. Previous to this the nucleus of the British Museum was founded in 1753 by the will of Sir Hans Sloane, and added to by the acquisition of Sir William Hamilton's collection and the Townley Marbles; and many other museums were established in different countries. With the opportunities for study came the intellectual impetus which has since gone on increasing. The great change in mental and critical outlook which took place towards the end of the eighteenth century was accompanied by a keen appreciation of Greek and Græco-Roman art. In 1766 Lessing published his *Laokoön*, which still, in spite of certain limitations and errors, remains a standard work upon the principles of art. The fact that he chose the Laocoön as the theme and title of his work is significant.[1] The struggling group of the father and his two sons, attacked by monstrous snakes, is compared by Lessing with Virgil's description of the same event; and he was able to recognise in this group those great characteristics of Greek art at its best which here seem to many modern critics conspicuous by their absence. Winckelmann and others spread the knowledge and appreciation of Greek sculpture; but a systematic and historical study, based alike on literary and on monumental evidence, was first attempted by Brunn, and on his work all subsequent study has been founded. His book, which was published in 1852, was called *The History of Greek Artists*. The title is appropriate; for the whole study had to be built up upon a chronological framework which was based on the references in ancient writers. His successors have to a great extent been employed on filling the gaps in our knowledge by fitting extant works into their proper places in the system. Furtwängler's great work called *Masterpieces of Greek Sculpture* was published in 1893; its aim is to identify and to classify, by comparative study, a number of sculptures scattered throughout the museums of Europe and America, and to establish their relations to one another and the leading characteristics of the different schools and periods. It required an extraordinary memory and critical faculty to deal with such a mass of material. A distinguished German scholar said at the time, "Furtwängler has built a mountain over which we all have to climb." But from this elevation it has been possible to survey the whole field, and to find guidance in a most complicated study. There have been several other histories of sculpture. Above all the full and scientific catalogues of museums, such as the British Museum, that at Berlin, and many others, and of the great collections such as the Ny Carlsberg at Copenhagen and the Barracco at

[1] The importance of Lessing's *Laokoön* for æsthetics is also discussed in the Article on *The Principles of Literary Criticism*.

Rome, have contributed to the recognition and classification of sculpture; also such works as the German catalogue of the Vatican, that of the Capitoline Museum by the British School at Rome, and Michaelis' *Ancient Marbles in Great Britain*. The study of ancient sculpture has become excessively minute and technical, and in many cases the wood cannot be seen for the trees.

CRETAN PAINTINGS AND VASES

The conditions of the study of Greek painting are very different from those applying to sculpture. With the exception of Crete at the one



Fig. 14.—FRESCO IN AKHENATON'S PALACE

extreme and Pompeii and Herculaneum at the other, very little is left to enable us to imagine its character. But to judge from the description of ancient writers it occupied a position in the ancient world as highly esteemed as that of sculpture. The great frescoes of Polygnotus and the Aphrodite Anadyomene of Apelles enjoyed the highest fame. But such knowledge as we have of these being entirely due to literary description, they hardly belong to the domain of archæology, except so far as their influence may be traced on contemporary vases. The decorative frescoes found in the palaces at Cnossus and elsewhere in Crete cannot be reckoned as Hellenic art; their spirited renderings of men and animals and their naturalistic treatment of vegetable forms find the closest analogy in the frescoes of Akhenaton's palace at Tell-el-Amarna in Egypt (*see Fig.* 14).

But they are not Egyptian, and their artistic style seems to have been developed in Crete itself. It was imitated in the frescoes of the palaces of Mycenæ and Tiryns; but its artistic tradition seems to have been completely lost and forgotten before the rise of Hellenic art in Greece. In the art of decorating vases, however, there seems to be an almost continuous succession, interrupted by some remarkable breaks, from the earliest times to the third century B.C. In the lowest strata of the palace at Cnossus there is pottery of the neolithic age such as is found in many Mediterranean districts, mostly black with geometric patterns incised and filled with white. This is succeeded by pottery of the so-called Minoan style, which is roughly divided into three periods, each of these divisible into three or more sub-sections. The Early Minoan (2500 B.C. or earlier) imitated to some extent the incised patterns by painting, either light on dark or dark on light. The Middle Minoan (2000 B.C.), especially in its middle period, when it is called, from the place where it was first recognised, Kamáres ware, is a fine biscuit ware of most skilful technique, with polychrome floral designs, mostly in red and white on dark ground. This type of pottery was found by Sir Flinders Petrie in Egypt in remains dated to the XIIth dynasty, or about 2000 B.C. by the usually accepted chronology (Petrie makes it 3500). And this synchronism has since been abundantly confirmed by discoveries of dated objects both in Egypt and in Crete. The Middle Minoan third period is distinguished by more sober and restrained style, especially by monochrome designs of lilies and other flowers in white on the natural colour of the clay, giving an almost Japanese effect. The Later Minoan age (1500 B.C.) is marked by the adoption into designs of vases of many vegetable and marine forms; the lily continues but is more conventionalised, and the octopus, nautilus, murex shell, brittle-star, and other marine animals are introduced in a decorative setting of seaweed. This develops into the rich and florid style, in which these same motives are used with more profusion and on a larger scale. This is called the Palace style, because numerous examples of it have been found in the latest and most splendid of the palaces at Cnossus. It has also been found elsewhere in Crete, and in the early graves at Mycenæ, where it was doubtless an importation. Similar finds of Palace style have been found in Greece, notably at Thorikos in Attica and at old Pylos in the Peloponnese. It has also been found in Egypt; and vases of the same characteristic shape and ornamentation have been found represented as tribute brought by Cretans on tombs of the XVIIIth dynasty, about 1500 B.C. The palace of Cnossus was destroyed, possibly by invaders, about 1450 B.C., and this event was followed by the years of highest prosperity and riches at Mycenæ and elsewhere in Greece. The style of pottery that accompanies this epoch is sometimes known as Late Minoan third period. It shows most of the motives of the Palace style repeated in a somewhat mechanical and conventional manner, and gradually loses its freshness and vigour until, in the general decadence of the Mycenæan civilisation, it gradually disappears, though not, as will be seen, without leaving some inherited traditions to its successors. The three Minoan eras belong properly to Crete, though stray examples of them are found elsewhere in the Ægæan area. An analogous division, however, has been traced in the surrounding regions, and is known as early, middle and

late Cycladic for the islands, taking its name from the Cyclades. Melos, at Phylakopi and elsewhere, has proved very rich in characteristic examples of naturalistic flower designs, corresponding to those of the third phase of Middle Minoan in Crete, and also in curiously conventionalised



Fig. 15.—CRETAN VASES (KAMÁRES)



Fig. 16.—MIDDLE MINOAN VASE

bird forms. A similar classification has been noted for the mainland of Greece, and is known as early, middle and late Helladic (*see Figs.* 15, 16, 17*a*, and 17*b*).

It is evident that this general classification must prove of the highest value to excavators and to students, and affords clear criteria for estimating

the age and affinities of any deposit. Any study of the subject, to be profitable, must of course be supplemented by actual familiarity with typical instances of all classes. This can best be obtained in the museums of Candia and Athens. But selections of fragments and of facsimiles have



Fig. 17*a*.—LATE MINOAN VASE

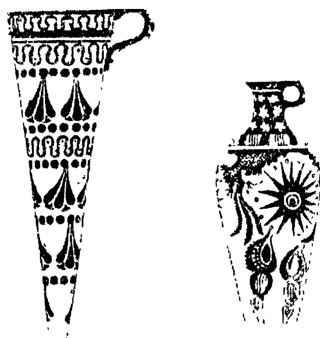


Fig. 17*b* —LATE MINOAN VASES

been arranged in Oxford, at the British Museum, and elsewhere, so that it is possible to grasp their main characteristics without a visit to the Ægæan.

GEOMETRIC AGE

Following on the decadence of the Minoan and Mycenæan civilisation, we find new elements of decoration intruding into the pottery of Greece. These belong to what is called the geometric style, in the more

restricted sense. The supplanting seems to have been gradual, for vases and fragments of the late Mycenæan and the early geometric are often found side by side both in Crete and on the mainland of Greece. The origin of this geometric style has been much disputed; there are two main theories, the one that it was brought in by the invading Dorians about 1000 B.C.; the other that it represents a revival of the earlier geometric style which had been overwhelmed for a time by the Mycenæan. This geometric pottery is found in many places, above all on the Acropolis of Athens and in the cemetery just outside the Dipylon Gate, whence it is commonly known as Dipylon ware (*see Fig.* 18). It often consists of very large vases, which were set up as monuments over tombs as well as buried within them. The subjects are not confined to stylised patterns



Fig. 18.—GEOMETRIC VASE, DIPYLON

such as the key, a kind of flattened spiral or mæander, or concentric circles connected by tangents, but also include aquatic birds, deer, and other animals; and in the more elaborate specimens are found figures of horses and men, great funeral processions, dances, and even sea-fights. The geometric pottery, which reaches its full vigour in about the ninth and eighth centuries B.C., comes almost everywhere, in its later phases, to be penetrated by orientalising influences. This is the case especially in Attica and Bœotia, and in what is called proto-Corinthian, which is widely spread in minute and delicate vases. Much of it was found in the Heræum at Argos, and more recently at Corinth and its neighbourhood. In colouring and in shapes of vases it recalls the later varieties of the Mycenæan, and may well have been developed from it, side by side with the geometric intrusion.

The orientalising style, which is in vogue about the seventh and sixth centuries B.C., falls into two main branches, the Doric or Corinthian and the Ionic or Rhodian, the former mainly prevalent on the mainland of Greece, the latter in Asia Minor (*see Fig.* 19). It may be said generally that the Corinthian is more compact in its shapes and more crowded and concise in its ornamentation, and given to the rendering of details by incised lines, the Rhodian or Asiatic freer and more flowing in design and given to the use of outline. Both alike have the ornamentation on



Fig. 19.—RHODIAN VASE

larger vases in the form of friezes one above another. The subjects in earlier examples are mainly friezes of animals either real or fantastic, ibexes, oxen, lions, leopards, birds, and sphinxes, gryphons, and other mixed forms. In both the human figure appears on later examples, sometimes merely for decoration, sometimes in definite scenes of combat or of mythological interest. Both styles develop on lines consistent with their character. The richly decorated and freely drawn work of Miletus and Rhodes is continued in the various Ionic schools of painting. At Clazomenæ many large terra-cotta sarcophagi have been found, some with historical battles—the finest is in the British Museum. This style is continued with some Egyptian influence in the pottery found on the site of Daphnæ in the Delta, where Psammetichus settled his Ionian mercenaries; this was deserted after 564 B.C., when Amasis transferred the Greeks to Naucratis, and consequently all the pottery found

there, which is very distinctive in style, must belong to the end of the seventh century or the beginning of the sixth. Naucratis also developed a characteristic vase painting, derived from that of Miletus and Rhodes. Great quantities of this pottery were found in the temples sacked by the Persians in 526 B.C.; hence this Naucratis ware must belong to the third quarter of the sixth century. Such historical data offer most valuable evidence as to the dates of the various classes of vases, not only of those made at Daphnæ and Naucratis, but also of those showing affinity to them or discovered with them.

STYLES OF GREEK VASES

In addition to the Corinthian, which are the most numerous and widespread, there were other distinctive classes of vases made on the main-

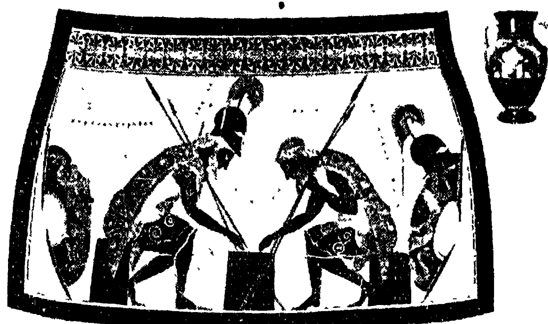


Fig. 20.—BLACK-FIGURED VASE. HEROES PLAYING DRAUGHTS

land of Greece. Among these are the Chalcidian, noted for its metallic forms and quaint and vigorous drawing, and the Attic or Athenian. These and the later Corinthian all adopted a style of decoration with black figures on a terra-cotta ground, drawn in silhouette with all details incised; white and purple were also added in places. These black-figured vases, as they are called, became very popular throughout the Mediterranean, and were exported in great quantities to Italy and elsewhere. Many of them were found buried in Etruscan tombs. Hence they, and the red-figured vases that succeeded them, were usually called "Etruscan" vases by the antiquaries of a century or more ago. This black-figured style was prevalent in the earlier part of the sixth century B.C. Another class of vases which had a more or less independent development was that of Sparta. Thanks to the careful record kept of the stratification of the vase fragments in the temple of Artemis Orthia, this Laconian ware can now be traced through the centuries, from the seventh to the fourth, in different stages of rise and decline. Its finest work, which belongs to the sixth century, has a fine white surface and beautifully designed ornamentation; its scenes are in the black-figured technique.

From the subjects on some of these vases, they were generally supposed to be of Cyrenaic origin. This is clearly not the case, in view of the Spartan discoveries, though it is still possible that some of the vases may have been made by potters who carried the Laconian tradition to Cyrene. In the sixth century Athens, with its famous potters' quarter (Ceramicus), began to monopolise the Italian market, and to drive the Corinthian and other rivals from the field. From about 550 B.C. onwards the history of vase-painting is the history of Attic vase-painting. For the two centuries that follow the study of this history has become highly specialised. Both potters and painters took to signing many of their finest vases ; and, with the help of their signatures, the vases have first been classified according to these ; then others have been grouped around them by comparative



Fig. 21.—RED-FIGURED VASE, BY BRYGOS
SACK OF TROY

study, until it has become possible to assign a very large number not only to their date, but also to their individual master. Certain general changes may be noted. The finest of the Attic black-figured vases had a bold design and exquisitely finished detail, incised almost like goldsmith's work (*see Fig.* 20). Other examples vary in excellence, and some were carelessly drawn. About the last quarter of the sixth century a revolutionary change in the design of vases was introduced. Instead of the figures being silhouetted on a light terra-cotta ground, the figures were first drawn in outline and then the background was blacked round them, all details and inner markings being rendered by fine brush-lines, often in relief on

the surface. It was in this red-figured technique that the most skilful vase-painters worked, and drew with a freedom of design and a certainty of hand that have never been surpassed (*see Fig.* 21). The actual dates of these different techniques were incorrectly estimated by earlier students, owing to the misconception that the finest vase-painting must be approximately of the same date as the finest sculpture in the Parthenon. But once more a national disaster came as a help to modern study. For in the débris buried on the Acropolis after the Persian sack of Athens, there were found signed vases by the greatest artists of the finest red-figured technique, which must therefore have been fully developed before 480 B.C., and must probably have originated some half-century earlier. Attic vase-painting continued to develop, though hardly to improve, after



Fig. 22.—ATTIC WHITE LECYTHI

this period. A strong influence was exercised by the painter Polygnotus, who came to Athens soon after the Persian invasion and painted many famous frescoes of historical and mythological scenes. The simple and dignified drawing, and the distribution of the figures as if on uneven ground, is imitated on some vases of this time, which may therefore give us some notion of his style. Towards the end of the century a more florid and picturesque effect is aimed at. A series of vases which lasts pretty well through the fifth century B.C. is that of the Attic white lecythi, or vases for ointments buried with the dead. These were painted in more or less polychrome effect upon a white ground; they can therefore give us a better notion than the red-figured vases of the arts of fresco and easel painting as practised at the time (*see Fig.* 22). In the fourth century the art of vase-painting in Athens lost its distinction and brilliance; but it

produced for the barbarian market, especially the Crimea, vases with coloured and gold enrichments; and some interesting imitations with Scythian subjects seem to have been made locally. But the South Italians at this time took to making vases for themselves instead of importing them. At Tarentum, in particular, enormous and pretentious vases were produced, often with interesting scenes from dramas or from the nether world of the dead. There were several other varieties of Italian vases, such as Apulian, Lucanian and Campanian, which did not entirely disappear until the Roman conquest.

This is an outline of the history of Greek vase-painting, and enough has been said to show how such a series of datings of various styles, checked again and again by reference to historical events, offers a constant succession of clues to the excavator and to the student. In order that these clues may be preserved and understood, the most careful record must be kept in all excavations. If the earth in which objects are buried is the result of gradual accumulation, it must be removed and recorded stratum by stratum. If its burial has been the result of sudden destruction or accident, the exact conditions must be considered; if the excavation is of a cemetery, the contents of the various graves must be preserved together and their relative position noted.

PRESERVATION AND RESTORATION OF VASES

The study of Greek pottery has so far been considered almost exclusively from the artistic and technical side, and especially from the chronological data it supplies. From this point of view, the most insignificant fragment can give as trustworthy and valuable information as a complete masterpiece of the vase-painter's art. The subjects of vase-paintings offer an almost inexhaustible field of study, ranging from gods, heroes and mythological scenes to the most trivial details of daily life. But before making use of this evidence as to the way the Greeks represented for themselves all these subjects, it is necessary to observe some caution. The history of the preservation and present condition of Greek vases is similar on a small scale to that of Greek sculpture. The vases were dug up in great quantities in the eighteenth century in tombs, mostly in Etruria, and accordingly were commonly called Etruscan. They were sought after by rich collectors, either for ornamental purposes or as works of beauty in themselves; but they remained almost entirely in private collections. For such purposes broken vases or fragments had little attraction. Many vases, thanks to the solid construction of the tombs, remained whole and undamaged. Many others were broken up, and portions of them were lost. Here the restorer again had his chance, and he used it sometimes with skill and discretion, sometimes indiscriminately. The reconstruction of the form of a vase, of which considerable portions are missing, requires skill and patience, but is in every way a desirable undertaking, especially if the new parts be distinguished from the old by some difference of colour. Restoration of the designs or scenes represented on the vases is another matter, and may be very misleading. For instance, on a vase from the Leake collection at Cambridge there was a representation of Ulysses and a companion thrusting a club into the eye

of Polyphemus. When the vase had been skilfully cleaned, the club disappeared, and there were left only two warriors attacking with spears a recumbent giant, probably Heracles and Telamon attacking Alcyoneus. The Cyclops motive was borrowed from another vase in the British Museum. This is a very simple and insignificant instance of false restoration; but it would be easy to multiply examples in which what is now visible is a mere travesty of the original design. Nor is the pernicious work of the restorer confined to modifying the composition or adding to it. When vases had been broken into many fragments and pieced together, often the joints were scratched in and then filled up with cement or some other material, and then the whole was covered over with an opaque coat of pigment, only approximately resembling the terra-cotta red and black of the original painting, so as to conceal the fact that the ware had been broken and put together again. Most of the vases in the great collections have been tested and cleaned by experts, so that what is now visible is ancient; but there are many still left which would not stand the test, or of which but a small portion would survive it.

Greek vases, like Greek sculpture, were for a long time accessible only to the few. Systematic study of them was facilitated by the transference of large series of them to public museums. Thus the Hamilton collection of vases was acquired by the British nation in 1772, and was later joined by many additions. The great Campana collection was not acquired by the Louvre until 1861. There are now fine collections of vases in most of the chief museums of Europe and America. Catalogues of many of them have been published; and within recent years a great international project for the publication of a systematic "corpus" has been planned and is being rapidly carried out.

SUBJECTS OF GREEK VASES

The subjects of the designs on Greek vases and their interpretation have attracted much attention from scholars. In earlier days fanciful explanations and attempts to connect them with the mysteries were prevalent. Some undoubtedly preserve for us aspects of Greek religion and life otherwise unrecorded; but mythology itself in recent years has become a more scientific and comparative study. Some of the commonest classes of subjects may be noted. In some cases they illustrate, or confirm, the information we obtain from classical literature, in others they supplement or modify it. They are sometimes derived from scenes of myth or of ritual which are preserved through no other channel; even when they reproduce a well-known tale, they often do not merely illustrate the text, but give a traditional and independent version of the story. A frequent characteristic is the desire to tell as much as possible of the story in a single scene; and this not by repeating the same figure in successive stages of action, but by what is sometimes called the comprehensive method, by grouping together several incidents without very close observance of the unities of place or time. An example may be seen in the representations of the sack of Troy. Here the various episodes were well known. Neoptolemos slew Priam at the altar in the palace; he also killed Astyanax by hurling him from the battlements. But the figure of

Neoptolemos appears only once, and he is hurling the boy, not over the battlements, but against the altar on which Priam is seated. There are many varieties of this scene in detail, but the combination of the two tragic events had evidently become impressed upon tradition, though it does not appear in any literary version of the tale. And, to fill up the picture on the vase, other episodes were introduced as required to fill the space or to satisfy the artist's caprice—Ajax dragging Cassandra from the image of Athena, the Trojan women taking refuge at the same statue, the escape of Æneas, carrying his father on his shoulders and leading his child, the rescue of Æthra by her grandsons. These do not recur in any traditional order, but are selected and arranged by the vase-painter to suit his convenience or to balance his composition.

The gods are frequently represented on Greek vases, either in single figures or in groups, or as taking part in some scene or action. Sometimes comprehensive groups of the chief gods are found, usually arranged in pairs; but there is no recognised canon of choice. They may be represented as banqueting on Olympus. Such groups are especially common when a great occasion is represented, such as the introduction of Heracles and his marriage with Hebe after his apotheosis, or the return of Hephæstus when he was brought back by Dionysus and his satyrs. The birth of Athena from the head of Zeus occurs in the presence of other gods, and her combat with Poseidon for the land of Attica. She also appears constantly as supporting heroes in their various exploits.

A scene of combat in which all the gods take part is the battle of gods and giants; and the separate single combats of the various gods and giants often appear.

The myths relating to Apollo and Artemis frequently appear on vases. Apollo rescues his mother from the giant Tityos, whom he slays. Apollo and Artemis, instigated by their mother, slay the children of Niobe. When Marsyas, having picked up the flute invented by Athena, challenges Apollo to a musical contest, he is defeated and flayed for his presumption. Artemis, surprised while bathing by Actæon, sets his own hounds on him. Apollo recovers his cattle, which had been stolen by the infant Hermes. Dionysus, with his rout of satyrs and Mænads, is perhaps the commonest of all subjects on vases, and appears in infinite variety. The myths of Demeter and Persephone also supply many themes. The rape of Persephone by Pluto is not often found; but, on the other hand, the return of Persephone to her mother and to the upper world occurs in many varieties of treatment. Sometimes she appears emerging from the earth or from a cave, escorted by Hermes as messenger and guide. In a curious variation she is welcomed on her return, or at least surrounded by satyrs or peasants with mallets—apparently a reminiscence of some country festival. In one case she is named Pandora and received by Epimetheus. In some vases, which contain Eleusinian gods and heroes, the birth of Plutus is represented. A large and sumptuous series of vases, mostly made at Tarentum, in South Italy, represents the underworld. In the midst, in a palace or shrine, are placed Hades and Persephone, surrounded by other figures of the world of the dead—the three judges, Minos, Æacus and Rhadamanthus, Orpheus and Eurydice, Medea and her children, Theseus and Pirithous, and also the great sinners, Sisyphus

and Tantalus, tormented by Furies. Among them sometimes appears Heracles dragging off Cerberus.

Scenes from the life and exploits of heroes supply many subjects to the vase-painter. The commonest of all, perhaps, are the Labours of Heracles. In addition to the canonical twelve, each of which has more than one recognised version, various other exploits or adventures are represented. Among them are his visit to Egypt, and overthrow of Busiris, his slaying of the giants Antæus and Alcyoneus—these in addition to his taking a regular part in the battle of gods and giants; his fight with Cycnos and Ares, which is often hard to distinguish from a battle of gods and giants, since most of the gods join in on either side until Zeus parts the combatants; his struggle with Triton, and also with the river god Achelous, in which last he won as his bride Deianira, whom he subsequently delivered from the centaur Nessus. He also fought with the centaurs and the Amazons, and freed Prometheus from his fetters on the Caucasus, after slaying the vulture that tormented him. A latish vase, of Italian make, represents his madness as it is told in the play of Euripides. This is but a selection from the great variety of adventures in which Heracles is the main figure. Theseus, especially in Athens, had also a canonical series of exploits, mainly on his journey from Trœzen to Athens; the club-man, the pine-bender, the sow, the wrestler Kerkyon, Sciron, who hurled travellers down the rocks that bore his name, Procrustes, who cut them down to fit his bed, all of them suffered poetic justice at the hands of Theseus. But his chief exploit was the slaying of the Minotaur in the Labyrinth, after he had accompanied the annual tribute of children from Athens to Crete. There are also representations of his visit to the home of Amphitrite beneath the sea at the challenge of Minos; of his receiving from Ariadne the clue to guide him through the labyrinth, and his desertion of Ariadne in Naxos. Theseus was, above all, an Attic hero; but the Attic vase-painters also illustrated many other legends. One of the most familiar is that of Perseus. We may see on vases Danaë receiving the shower of gold, and being enclosed in the chest and floated off to sea. Many of the details of Perseus' seeking and slaying of the Gorgon Medusa are to be seen. A favourite subject, especially on early vases, is the flight of the hero across the sea, pursued by the other two Gorgons. Then there is the rescue of Andromeda from the sea-monster, the return home, and the turning of Polydectes to stone by means of the baleful head. Another great expedition was that of Jason and the Argonauts to recover the golden fleece; this offered many subjects to the vase-painter—the freeing of Phineus from the Harpies by the sons of the North Wind; Medea's help to Jason in overcoming the dragon; her adventures after she had fled to Greece with Jason; her destruction of the bronze man Talus, who defended the shores of Crete, and her deception of the daughters of Pelias; finally her quarrel with Jason and slaying of her children, as represented in the play of Euripides.

The Theban legends are not very commonly found on Attic vases, perhaps because no love was lost between Thebes and Athens. Œdipus and the Sphinx appear on an Ionic vase. The tale of the Seven against Thebes has inspired a quaint picture of the bribing of Eriphyle; Polynices tempts her with the necklace of Harmonia, and on a Corinthian vase

with the departure of her husband Amphiaraus the necklace she holds tells the tale of her treachery. Dionysiac scenes are not particularly associated with Thebes, except in the case of Pentheus.

This miscellaneous set of legends, many of which are only incidentally referred to in literature, might be almost indefinitely multiplied. But enough has been said to show the vast repertory from which the vase-painter could select. In addition there are all the vases which deal with the tale of Troy, as told in the poems of the Epic cycle, and especially the Iliad and Odyssey. These start with Peleus' capture of the sea-goddess Thetis, the marriage feast at which the dispute arose between Hera, Athena, and Aphrodite, and the judgment of Paris that followed—a theme repeated again and again in various types. Then follows the elopement of Helen with Paris. The Iliad inspired many scenes which, apart from the names added, could not be identified with certainty; for one battle scene is much like another. Often we simply find single figures or small groups of heroes, such as Achilles and Ajax playing draughts, or Achilles binding the wound of Patroclus, or the separation of Hector and Ajax after their single combat. The capture of Dolon, the embassy to Achilles, the attack on the ships, are all clearly represented; also Sleep and Death carrying away the corpse of Sarpedon. The final duel of Achilles and Hector is identified by the names, but the details of the Homeric narrative are not followed by the artist. The dragging of Hector's body, and Priam's visit to Achilles to redeem it, add pathos to the story; and there are representations of Hector and Andromache, alone or with other Trojans. The Odyssey, from its varied and distinctive episodes, is easier to illustrate than the Iliad. Among characteristic scenes may be quoted the adventures with the Cyclops, with Circe, and with the Sirens, the visit to the region of the dead to consult Tiresias, the meeting with Nausicaa, the loom of Penelope, the recognition of Odysseus by his old nurse Anticleia, and the slaying of the suitors.

Historical scenes are sometimes found on vases; but mostly such as had already become almost mythical in character. Thus the representation of Crœsus seated on his funeral pyre does not correspond closely either with the account in Herodotus or with that in Bacchylides. Combats of Greeks and Persians occur on vases, but the great example of an imaginary historic scene is the vase at Naples which represents King Darius and his Court making preparations for the invasion of Greece. This was made in South Italy, probably about the time of Alexander, when people were reminded by current events of the time of the older Persian wars.

Scenes from daily life are very common on vases, and serve to illustrate almost every form of work, activity, or enjoyment. The art and practice of the potter himself is not neglected; we can see representations of quarrymen chopping out clay from the pits, of potters throwing vases upon the wheel; of the furnace with vases being baked in it, of the vase-painter's studio, with master and apprentices at work; and, finally, of the vases being exported by ship, sometimes hung in the rigging to avoid risk of breakage. Agriculture is represented by ploughing and sowing, by the gathering of crops of olives, apples, and other fruits, and by scenes of vintage and wine-presses. Among trades and occupations we find

shoe-making and shopping. Many vases, as was to be expected, are concerned with athletics, and almost every type of contest is found—running, jumping, wrestling and boxing—in addition to chariot and horse races. A class of vases, known as Panathenaic amphoræ, were given as prizes in the Panathenaic festival at Athens. These have a large image of Athena on one side and on the other a representation of the contest for which they were given. They were evidently highly prized by the victors, for they were exported to all parts of the Greek world. Dinner-parties, symposia, and dances are often found in vase pictures, and also many games; sometimes there are religious processions and festivals, military exercises and reviews. Funeral rites are especially found upon vases made for placing in tombs or dedicating outside them, such as the Athenian white lecythi; on them may be seen the lying in state of the corpse (prothesis) surrounded by mourners, the funeral procession, the deposition in the tomb, sometimes by figures of Sleep and Death, and the approach of the survivors with offerings to be placed in the tomb, usually wreaths or sashes. In short, there is hardly any event of interest which cannot be illustrated from vase-paintings, or about which they do not give us valuable information.

USE OF VASES

It is sometimes asked what use the Greeks made of painted vases. A certain misapprehension arises from the fact that the great majority of the vases in our museums have been found buried in tombs. Certain classes of vases were certainly made for the purpose of burial with the dead, owing to the custom prevalent in many places and periods of supplying vessels and furniture for the dead in their long abode. But representations on the vases themselves often show them as in actual use or standing about in a house; the dead were merely supplied with what they were used to in life. Doubtless the larger and finer vases were intended either for ornament or for dedication in temples; an immense number of vase fragments of all periods were found on the Acropolis at Athens, and in the temples of Apollo and of Aphrodite at Naucratis; owing to the conditions of destruction and discovery, it was inevitable that such dedicated vases should be broken up and only survive in fragments. But there can be no doubt that the vases were originally intended for actual use, though many of them, owing to the demand for vases to be buried, were provided for the export trade to Etruria and elsewhere.

GEMS

Two classes of antiquities that are closely related, from the artistic point of view, are gems and coins; for the coin, in its essence, consists of a lump of metal stamped with the seal of a city or a ruler. Gems may be either in precious or semi-precious materials, and in harder or softer stones. The engraved design is always in early times in intaglio, or cut in so as to produce an impression in relief on wax, plaster, or some other soft material. The usual form of a seal-stone in Mesopotamia was the cylinder, from which the design could be rolled out on to the impression, and repeated identically if required. The Egyptian form was the scarab, so called because the rounded back was carved to represent the folded wings of the

sacred beetle, the design being incised upon the flat side. Both forms were used in Greece in early times, and the shape of the scarab was often used in the finest period of Greek art, especially in what is called the scarabæoid, which preserves the shape but omits the details of the beetle.

Cretan gems, which are very numerous, are often in the earlier examples pyramidal in shape. In the later Cretan and Mycenæan gems the shape is often circular or else lentoid (lentil-shaped), and convex on both sides. The designs found in Crete are often religious or symbolical in nature, many of them containing symbols in the Cretan script. Mycenæan gems are more given to representations of animals, often in contorted positions —lions, oxen, or deer. The harder stones, which were worked with the wheel, are most skilful examples of the gem-cutter's art. Gold signet rings have also been found, especially at Mycenæ, with more or less elaborate scenes upon them. After the Mycenæan period comes that of the island gems, mainly found in Melos; these carry on the tradition, but in softer stones and, for the most part, less skilful work. They offer, however, a most valuable link between the Mycenæan and the archaic Greek. The art of the Greek gem engraver goes through much the same stages as that of the sculptor and painter. In the earlier time it is stiff and angular in poses; in the fifth century it attains the highest degree of beauty of design and technical skill; in later times it becomes softer and freer in design. Cameo cutting, in which the figures stand out in relief, often in differently coloured layers of stone, does not appear until the Hellenistic age. Some very large ones were made with Ptolemaic portraits, as were also large allegorical groups; the same technique was continued with great sumptuousness in Græco-Roman or Roman imperial art. Greek gems have always been in great demand among collectors, and for that reason many forgeries have been produced.

COINS

The study of numismatics is far too complicated to be more than touched upon here; but Greek coins offer such invaluable evidence as to art, history, and commerce that it cannot be altogether passed over (*see Fig.* 23). It is difficult for us to realise how great and prosperous civilisations can have been carried on in early times before the invention of coinage; all commerce must have been dependent either on barter or on carrying about gold and silver ingots and portable scales. Units of value were often slaves or cattle. In a very early Greek inscription in Crete, fines are reckoned in tripods and caldrons. It has been suggested that the earliest Greek coins were equivalent to a bull. The invention of coinage was attributed by tradition either to the Lydian kings—one of whom was Crœsus—or to Phidon of Argos, who struck coins in Ægina. The essence of the invention, which probably dates from the seventh century B.C., is the impressing on a lump of metal—in early times usually gold or silver, or electrum, an alloy of the two—a device or symbol which was officially recognised as a guarantee of the weight and quality of the metal, and so obviated the necessity of weighing or assaying it. The enormous variety of Greek coins that is known is due to the fact that every independent Greek city claimed the right to issue coins, and most



Fig. 23.—COINS OF CYZICUS, AEGINA, CROTON, ELIS, GORTYNA (CRETE), SAMOS, PANTICAPÆUM, MACEDONIA.

of them exercised this right and vied with one another in the beauty and variety of their types. The origin of these types has been a matter of much dispute. Some authorities have regarded them as religious; and this seems the obvious explanation when the head of the chief deity of the city appears on its coins, as is the case with Athena at Athens, Hera at Argos, or Zeus at Elis. Others are generally regarded as commercial, especially when the type represents the chief product of the city, like the tunny-fish at Cyzicus, the ear of corn at Metapontum, or the Silphium, a medicinal plant, at Cyrene—though in this last case the head of Zeus Ammon appears on the other side of the coin. Probably no one explanation fits all cases, but various local or other considerations led to the choice of the device, or "arms," of the city which was placed upon its coins; sometimes it seems to be merely what is called in heraldry a "canting" device, as when the parsley leaf appears on the coins of Selinus or the seal on those of Phocæa, "Selinon" meaning parsley and "Phokos" a seal.

The difference in shape between ancient and modern coins is mainly due to the process of striking. First of all a metal die was prepared and engraved in intaglio, just like a seal-stone. This was fixed in an anvil, and then blanks of gold or silver or other metal were cast, of the requisite weight, usually round or lentoid in shape and convex on both sides. These were driven into the die by means of a punch and a hammer. This punch, except in the earliest examples, had another device engraved upon it, and thus were produced the obverse and reverse designs. The relief was usually much higher than on modern coins, and consequently ancient coins could not be piled, though in later times they became flatter in surface. In early South Italian coins, the obverse design was often repeated in hollow relief upon the reverse, the punch being in relief and not in intaglio. No collar was used to prevent the blanks from spreading when struck; hence the irregular shape often found in Greek coins. But the height of the relief gave the utmost scope to the skill and taste of the artist, and contributed to the extraordinary beauty of many Greek coins.

The earlier scholars gave much study to Greek and especially to Roman coins; but in this case also the last half-century has seen great progress, and much co-operation. The great collections have been scientifically catalogued. Above all, a minute study has been made of the coinage of various cities, all the historical data have been brought into relation with the indications to be found upon coins, and the successive periods of the history of the city have been traced in its coinage. This is most conspicuous in the case of outstanding events; for instance, Syracuse issued two magnificent series of dekadrachms to commemorate two great deliverances from its enemies—the Carthaginians in 480 B.C. and the Athenians in 413 B.C., and the same city placed the Corinthian Pegasus on its coins when Timoleon from Corinth came to their aid; or, again, the introduction of the Samian lion's scalp on the coins of Rhegium and Messene is probably to be explained by the arrival in these towns of a party of exiles from Samos in 493 B.C. And political conditions like the Bœotian League or the Ionic revolt have left their traces on the coinage of the cities concerned. Many other events, some of them recorded by literary history, some otherwise unknown, are reflected in the history of coin-types. It is evident that coins have in this way contributed in the

highest degree to the certification and supplementing of history, and above all to the exact dating of many events. The different monetary standards used by different cities have been thoroughly studied, and most important inferences drawn from them as to commercial relations, trade routes, and influences. Coins offer a dated compendium of the history of art from the seventh century onwards. Many statues have been identified by their help. From the time of Alexander, they also supply a vivid and authentic portrait gallery of Hellenistic rulers, which is continued in the portraits of Emperors on the Roman imperial coinage. In addition to what may be learnt from their types and inscriptions, the evidence of coins is most useful when they are found, either individually or in hoards, in excavations or elsewhere; they offer the same indications for dating as vase fragments, but under even more precise conditions.

MINOR ANTIQUITIES

The study of minor antiquities, such as bronzes, terra-cottas, and carvings in bone and ivory, has also been systematised and become more exact in recent times. The larger bronzes follow much the same development in style as sculpture generally; but statuettes and decorative bronzes have been found in great numbers and classified according to their technique, age and place of origin. This was especially the case in great excavations like those of Olympia, Delphi, and the Acropolis of Athens; early carvings have been found at Ephesus and Sparta; terra-cotta statuettes and other objects have been found in immense numbers upon almost all excavated sites and supplement or verify the knowledge we derive from other sources; they range from Mycenæan and geometric right through the classical age to Roman times. How much a study of these minor antiquities can contribute to our knowledge may be realised by a visit to the exhibition illustrating Greek and Roman life in the British Museum in London or to similar exhibitions in American museums.

INSCRIPTIONS

Inscriptions, both Greek and Roman, were not ignored by the earlier scholars, but the gigantic project of gathering together in a corpus the whole body of inscription dates from the earlier part of the nineteenth century. Systems of writing appear to have been in use as early as 3500 B.C. The Egyptian hieroglyphic and the Mesopotamian cuneiform (or wedge-shaped) were, however, a mystery until comparatively modern times. It is one of the greatest achievements of the early and middle part of the nineteenth century to have deciphered and interpreted them. The first clue was given by the Rosetta stone, found in 1798, and now in the British Museum. It is bilingual—that is, it contains versions of the same document in Egyptian hieroglyphic (the system of the priests), hieratic or demotic (the system of books or of the people) and Greek. This enabled Champollion and other scholars to recover the Egyptian language and the method of writing it. The Egyptian and Mesopotamian scripts were a combination of ideographic symbols (each representing a certain idea) and phonetic (each representing a certain sound). Other systems, such as the Cretan and the Hittite, existed in the second millennium B.C. The first

people to have invented and used a purely alphabetic system of writing were the Phœnicians, the earliest long Phœnician document being the Moabite stone, dated about 850 B.C., though some fragmentary inscriptions may be considerably earlier. The Greeks borrowed their alphabet from the Phœnicians, with slight modifications, about the end of the seventh century B.C., each Greek city adopting it in a different form; and this local variation continued until about 400 B.C., after which date the Ionic alphabet, which we use to this day in printing and writing Greek, was generally adopted. The Roman alphabet was borrowed, with some modifications, from that of Cumæ and other Chalcidian colonies in Italy.

Inscriptions served in ancient times as the chief means of publicity, both for information and for record. There is hardly any aspect of religion, or of public or private life, that is not illuminated by the evidence of inscriptions. As to religious matters, we find records of the worship and recognition by the State of various gods; the foundation, endowment, and administration of temples; and innumerable dedications of statues and offerings of all sorts. Some are of great historical interest—for example, the names of the cities which took part in the battle of Platæa, inscribed on the support of the tripod dedicated to Apollo on the occasion. This was set up at Delphi, and is now in the Hippodrome at Constantinople. Another instance is seen in the Roman arms dedicated by Pyrrhus of Epirus to Zeus at Dodona after his Italian campaign. Numerous temples and precincts had their own regulations, which were set up in a conspicuous position. There were lists of priests and other officials, and regulations for their appointment, duties and privileges, and for ritual of all kinds, might be prescribed.

A peculiarly interesting set of inscriptions records the cures made by Asclepius at Epidaurus. There were also many private associations for religious purposes, each of which had its own prescribed constitution and ritual observances.

On the political side, there are innumerable documents containing decrees and laws of the various States. An early example is a code of laws found at Gortyna in Crete, with many details as to laws of inheritance. It was the regular practice at Athens and elsewhere to inscribe all decrees of the Senate and people on marble, and to set them up in the market or some other conspicuous place. Public accounts and inventories of treasure were treated in the same way, as well as decrees and specifications of public works of all sorts and building accounts. We have, for instance, the accounts of the building and sculpture of the Parthenon and the Erechtheum. It was a common practice in Greece and in Rome to set up honorary inscriptions to men who had done good service to the State; and the office and privileges of proxenos (nearly equivalent to a modern consul) were frequently given to those who had made themselves useful to another city. Artists' signatures have given much information about the history of sculpture. The whole system of the training of Athenian youths, which subsequently developed into the University of Athens, is recorded in the so-called Ephebic inscriptions. In some cases we find a direct historical record, like that which Augustus had set up in many cities, to record the chief events of his reign; this is commonly

known as the Monumentum Ancyranum, because the best known example of it was found at Angora (Ancyra). Inscriptions in many places have recorded the famous Edict of Diocletian, an attempt to fix the price of all commodities throughout the Empire; this was in some cases in Greek, in others in Latin. Tomb inscriptions are innumerable, many of them containing interesting epitaphs.

Most of the above classification applies equally to Greek and to Roman inscriptions. On the Roman side an immense amount of light is thrown on municipal organisation and institutions throughout the Empire.

Milestones make it possible to trace the construction, direction and date of the network of Roman roads. Military inscriptions are also very numerous. Many of them, as Dr. Haverfield says, "are absolutely devoid of striking features. But when these hundreds are considered together they become important. If you tabulate some hundreds or thousands of birthplaces, you can trace the whole policy of the Imperial Government in the matter of recruiting. You can ascertain the answers to numerous important questions—to what extent and till what date legionaries were raised in Italy, what contingents for various branches of the service were drawn from the provinces, and which provinces provided most; how far provincials garrisoned their own countries, and which of them, like the British recruits, were sent as a measure of precaution to serve elsewhere; or, finally, at what epoch the Empire grew weak enough to require the enlistment of barbarians from beyond its frontiers." This is but one example of the way in which a great co-operative effort can reach results which no isolated study or chronicle of facts or theories could attain, and how a few great leaders, followed by numerous assistants and disciples, can give a new outlook and a new inspiration to whole spheres of intellectual activity.

THE GREEK HOUSE

Another aspect of Greek life upon which much light has been thrown by recent excavations is the plan and character of the Greek house. The great Cretan palaces, with their courts and complexes of chambers, workshops, and store-rooms, stand by themselves. But the less extensive and simpler palaces of Tiryns and Mycenæ show already, in their court and hall opening out of it, the essential features of the houses and palaces described by Homer, and also of the Greek house of historic times. This development had been obscured by a mistaken notion that both of these usually consisted of two courts, one for men and one for women. This misconception was based partly on the false analogy of Pompeii, where the two courts (atrium and peristyle) follow a Roman type, partly on a misunderstanding, or rather a misquotation, of Vitruvius. The excavations at Priene and at Delos have given us many examples of well-preserved Greek houses, mostly of the fourth century B.C. or later (*see Fig.* 24). But they almost all conform to the type of an open court, usually surrounded by a peristyle in the larger examples; out of this, usually at the north side so as to catch the sun and escape cold winds, opens a large chamber, often with a pillared porch in front of it, used probably as a living-room and also for entertainments, and several other rooms beside it or around

the court. There was often an upper story approached by a staircase. In some cases this was assigned to the women, in others they had certain chambers reserved for them. But that they were regularly to be found in the court is attested by literary evidence, though on special occasions they were probably confined to their own quarters. The decoration of these houses, often in imitation of marble panelling, resembles what is found in the earlier style of marble painting at Pompeii.

From all these sources it is possible to realise something of the life of the ancient Greeks. In the best days of Athens the duties of a citizen took up most of his time—attending the public assembly, serving his turn as a magistrate or juror, taking part in religious festivals, or being called out for military service. It followed that a man spent little of his

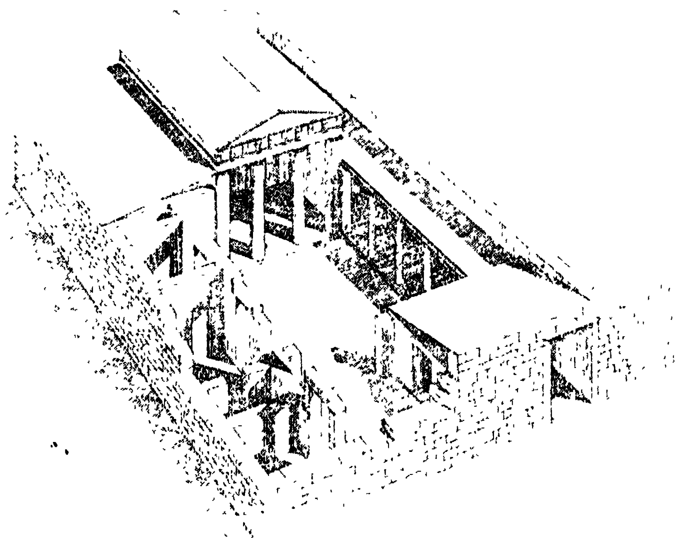


Fig. 24.—GREEK HOUSE AT PRIENE

time in his house, which was mainly given over to the women, especially in the daytime; but many houses had a dining-room in which guests could be entertained, and such dinners, followed by symposia, were a common feature of city life. Most men also passed a considerable portion of their time exercising in the gymnasium. Country estates existed, but these, as well as commercial pursuits, were mostly managed by overseers or agents with the help of slave labour. Hunting, especially the pursuit of the hare on foot and with hounds, was a favourite pastime.

ATTIC TOMBS

Another side of Greek life, which is little touched upon in literature, is represented upon the reliefs set up over Attic tombs. These frequently represent family scenes, and give a moving record of domestic affection.

There is often either no reference to death, or only the most indirect allusion. The survivors prefer to think of the deceased as they were when alive, in their favourite pursuits or amusements. Groups of two or more figures sometimes contain some allusion to a departure or a journey, in a solemn hand-clasp and a gentle melancholy. These tomb-reliefs are not, as a rule, the work of great artists, but they are the product of a time when Greek art was at its best, and they testify to the good taste and feeling of the people as a whole. The greatest number of them was found in the Ceramicus at Athens, just outside the sacred gate through which passed the road to Eleusis.

MYTHOLOGY

Another study which, though it does not deal directly with visible and tangible objects, is generally reckoned as a branch of archæology, is that of mythology. The evidence of vase-painting as to this subject has already been noted; reliefs also, especially votive reliefs, often give information concerning local beliefs and rituals. The earlier mythologists were often content to make fanciful explanations both of myths and of the ritual associated with them, and often some theory, such as that of the solar myth, was used almost as a universal key to their interpretation. But a systematic and comparative method of study has led to more scientific results. The primitive rites practised everywhere by peasants, especially at critical periods of the natural year, often bear a striking resemblance to the tales that they tell, and also to the myths which we find in a more artificial and poetical form in Greek mythology. Sir James Frazer's *Golden Bough* is an example of the mass of material that may be used in such investigations.

NORTHERN AND WESTERN EUROPE

So far we have been mainly concerned with classical archæology, but epochs which fall within the historical period in Greece and Rome and in the Mediterranean region must still be counted as prehistoric in the north and west of Europe. Much study has been given to these, but much still remains obscure; for instance it is still a matter of doubt, in the case of the beginning and end of the bronze age and the beginning of the iron age, how far the advances made are contemporary in the Mediterranean region and in central and north-western Europe. The interval between the two is not probably so great as is sometimes supposed. For objects of barter seem to have travelled along the great trade routes between the Baltic and the Ægæan in both directions. Baltic amber is often found in the south from Mycenæan times onward; and Mycenæan patterns, or others closely resembling them, are found as far away as Celtic Ireland. The most characteristic examples of the civilisation and handicrafts of these regions are associated with the names of two places where they have been found most abundantly: Hallstatt, in Austria, and La Tène, in Switzerland. The first, which belongs to the later part of the bronze age, is generally dated about 900–700 B.C.; the latter, which belongs to the early iron age, about 400–300 B.C., and both show the influence of Ægæan art of a contemporary or slightly earlier age. The metal objects of

these styles, and the pottery that accompanies them, have been published and recorded, and supply a foundation for the study of the handicrafts of Scandinavia and Celtic Britain as well as for central Europe.

This sketch gives an outline of the achievements of archæology. Many branches of the subject have been passed over altogether, others have been but lightly touched upon, but enough has been said to show that the discoveries of the past half-century have been of the most remarkable character, and exceed perhaps those of any other epoch in the history of the study. Nor do these discoveries seem likely to be at an end or even to have come to a pause. The last few years have seen the most sensational finds in Egypt and Mesopotamia, and the limits of our knowledge seem to be pushed further and further back, to show even in the remotest ages the most surprising technical and artistic attainments.[1]

MOST RECENT DISCOVERIES; EGYPT

In the case of Egypt, the life of the people has been recorded and portrayed with vivid detail in the paintings which decorated the inside of the tombs. These, owing to the dryness of the climate, have been preserved uninjured except by the hand of man, and have been studied and copied so that they are readily accessible to study. The same conditions have affected the preservation of many other objects, such as furniture and small articles of all sorts in wood or other materials elsewhere perishable. In earlier days it was mainly the pyramids and colossal temples which impressed the imagination; but little was known about the administration or civilisation of the country beyond what could be learnt from Herodotus and other classical writers. The great mass of documents that has been discovered in recent years, both inscribed on stone, scratched upon potsherds (ostraka), or written on papyrus, has supplied detailed information as to history, administration, religion and social life. An immense number of small objects, vases, beads, scarabs, ushabti (or tomb statuettes), have been studied and dated according to their types and materials, so that it is now possible to reconstruct in imagination the characteristics of almost all periods, from the earliest to the latest dynasties. In addition to this, there have been made some special discoveries of extraordinary richness. One, which aroused the widest interest, was the tomb of King Tutankhamen, the son-in-law of the heretic Pharaoh Akhenaton. As a rule tombs in Egypt, especially those of the kings, had been rifled, many of them in ancient times, and only gleanings are left for the modern excavator. Consequently the news that an unrifled tomb had been found aroused the highest expectations, and these were fully justified by the result. In the ante-room there was, closely piled together, a great mass of furniture, beds, chairs, chariots, and other objects, all of the most elaborate character and richly inlaid or plated with gold and other materials; the style however lacks the severity and simplicity of earlier work, and shows the influence of the somewhat affected work made under Akhenaton. Within the tomb chamber itself was a richly ornamented shrine enclosing the actual sarcophagus, ornamented with winged figures

[1] See also the section on Egypt and Mesopotamia in the Article on *The Arts of Painting and Sculpture*, p. 921.

of guardian goddesses, and plated with gold. The whole contents of the tomb have now been transferred to the Cairo Museum, and probably constitute the most remarkable set of objects ever found together.

The work of the time of Akhenaton shows a strange but most interesting phase in the history of Egyptian art. This king, about 1400 B.C., substituted for the traditional worship of the Egyptian gods a kind of monotheism, and appears to have attempted something of the same sort with the traditions of Egyptian art. This may be seen chiefly in the sculpture and painting found in his palace at Tell-el-Amarna. The portraits of the king and his family vary considerably, from a refined and spiritual idealism to what is hardly short of caricature. The king's figure, for example, seems almost to be a pathological study of an abnormal development; but his face as well as that of his queen,



Fig. 25.—HEAD OF NEFERTYTI

who must have been closely related to him, has a subtle charm, in spite of the abnormal development of chin and neck (*see Fig.* 25). The decorative paintings of the palace at Tell-el-Amarna are also strangely unlike Egyptian work, especially in the naturalistic representations of plants and animals. These last show a remarkable resemblance to contemporary designs in the palace of Minos at Cnossus. There is, indeed, no difficulty in the supposition that Akhenaton imported Cretan painters to decorate his palace. The resemblances are too many and too close to be accidental, and the style may well have originated in Crete. But no such explanation can account for the treatment of the human figure at Tell-el-Amarna. Nothing like it is known in Crete, nor is there any other known art which may have influenced Akhenaton's sculptors. The whole episode of this strange artistic innovation, which began and ended with the reign of Akhenaton, remains a problem for archæologists.

It is difficult to speak in any general terms of the life and civilisation which lasted through many thousands of years. Many changes no doubt took place; but the extraordinary conservatism of the Egyptians preserved many customs almost unchanged from the earliest dynasties down to the reign of the Ptolemies. Conditions must evidently have differed greatly in the different classes of the population, from the king and his officials and the priests at the one extreme to the serfs at the other. Between the two were middle classes which varied considerably in number and importance from time to time, according to the prosperity and external relations of the kingdom. But all alike were affected by the stereotyped routine which was necessitated by the geographical conditions. The very existence of Egypt depended on the dams and canals which were necessary for the control of the Nile and its inundations; hence the institution of forced labour (corvée) which continued until modern times. Work on the land was dependent on the same causes. During the inundation, from July to October, nothing could be done beyond the watching and repair of the dykes. Then, in November, came the time for sowing of all sorts of crops, and the people moved back on to the land; and the harvest followed in April. From the representations on tombs, we can realise how the officials and other rich men themselves supervised the work that went on in their estates, with the help of numerous scribes and other attendants. They must also have had large staffs of handicraftsmen and artists in their employ. Most of the arts and handicrafts were hereditary, and this conduced greatly to the conservatism and traditional skill which characterise most Egyptian work.

The houses of rich men and officials were on the most lavish scale, and included, in addition to living-rooms, courtyards, groves and gardens, and work-rooms and stores for all purposes. The houses of the middle and lower class were less magnificent, but similar in character, being usually built round a closed courtyard, with or without columns, with dwelling-rooms on the first floor, and flat roofs, with or without a canopy, made accessible by a staircase. These can be seen not only in paintings but in terra-cotta models, supplied sometimes in the tombs of poorer people, to provide them with accommodation similar to what they were used to in life.

Though all classes in Egypt, from the king to the serfs, appear to have been bound by an inexorable routine, the impression conveyed by the pictures is not a gloomy one, but rather of a cheerful and busy out-of-door life, full of industry and enjoyment. Relaxation and entertainments of various kinds seem to have been common. In the houses of the well-to-do, visitors were received and feasts or banquets were provided, at which the company sat on the ground on mats. There were decorations of wreaths and flowers, and music and dancing followed. Such entertainments can only have been given by the richer classes; but picnics and similar diversions were enjoyed by the common people, and festivals, sacrifices, and other gatherings were widely attended; an example is offered by the great festival at Canopus, which in later times degenerated into a wild sort of orgy.

The climate of Egypt, which suited such open-air life, was also suitable for very light garments. These varied from time to time according

to the prevalent fashion. Men at all times often wore nothing but a kind of loin-cloth or kilt, sometimes tightly folded or pleated. A vest might be added, and a wide necklace was often worn. Women usually wore a single straight and narrow garment, falling nearly to the ankles. Nude figures sometimes occur. But the drapery is often treated as if transparent, and the artist shows a delight in the bodily forms which offers the greatest contrast to the enveloping masses of clothing that conceal all but the hands and arms of Mesopotamian statues.

MESOPOTAMIA; UR

The recent achievements in archæology in Mesopotamia resemble in

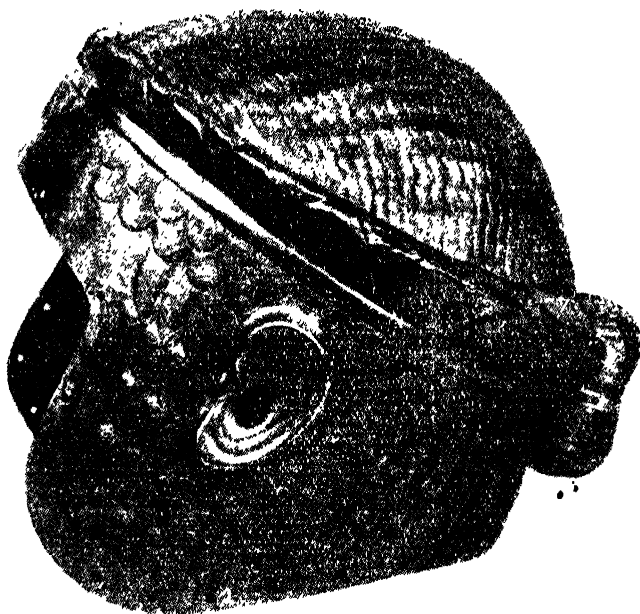
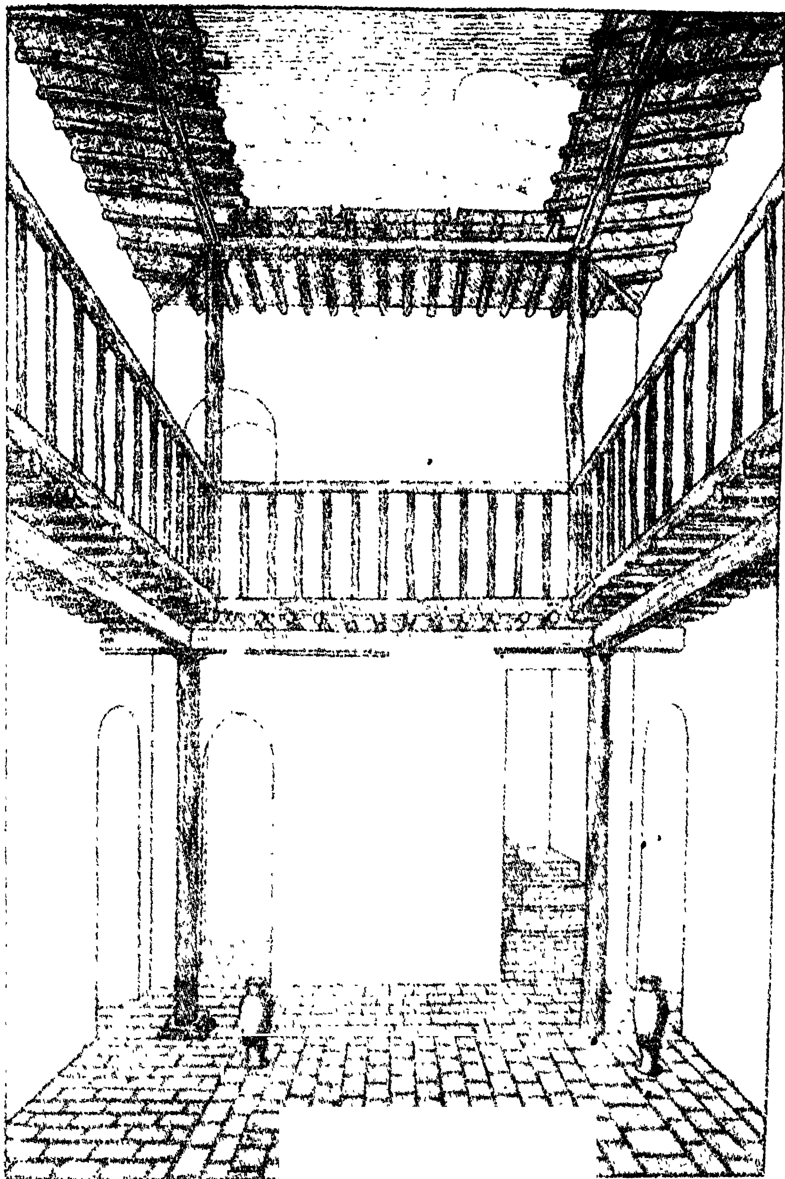


Fig. 26.—THE GOLDEN HELMET OF MES-KALAM-DUG

one respect those in Egypt—they have carried back our knowledge many thousands of years. The colossal winged bulls and extensive historical reliefs of the Assyrian kings were among the most imposing acquisitions of the last century; but they show for the most part a conventionalised style, in spite of their very spirited rendering of animals wild and tame. The origin of this style may be now traced back to the early Sumerians, and to cities and dynasties of a most remote age. The work of this period has been discovered in recent years by explorers of various nationalities. The most recent and in some ways the most astonishing finds are those of Mr. Woolley at Ur. The town, with its streets and houses, is preserved to a great extent. The finest examples of handicraft come from the royal

tombs, and are dated about 3500 B.C. But they show the highest skill in design and technique, both in metal, mostly gold and silver, and in inlaid work in various materials. Figures and heads of animals are beautifully modelled. An excellent example is a gold helmet (*see Fig.* 26), closely fitting the head and richly decorated. For inlay work, the most complete is the so-called " Standard of Ur." This represents, in shell and lapis lazuli, a series of scenes most delicately worked, representing the close of a campaign on one side, and a scene of peace on the other. Other similar friezes show cattle, sheep and goats as well as warlike subjects. The men are usually represented, as they are in Sumerian sculpture, clad in loose woolly garments hanging in tufts and completely enveloping and concealing the figure, in contrast to the clinging or transparent dress of Egypt. In the royal tombs, a confirmation of the early date is, in Mr. Woolley's opinion, to be found in the custom of human sacrifice, of which there is no trace in later Mesopotamia. In one of the royal tombs an armed bodyguard and many slaves and attendants, male and female, seem to have been butchered where they stood in the approach to the tomb. Among other finds are harps decorated with animal and other designs, a wreath or head-dress of gold on a princess, weapons, implements and vases, many of them of gold or silver. The whole impression produced is of a degree of wealth and of artistic skill that must, even at this early age, have had many centuries of growth and development behind it. The most conspicuous building at Ur was the huge Ziggurat, a massive cube of brick about 150 by 200 feet, and 75 feet high. Its walls, sloping slightly inward and divided by projecting buttresses, give a great feeling of stability; and they already show the principles of design found in later Mesopotamian work. It also has huge staircases leading up to the terraces. The temples and palaces are very complicated structures; but houses of the middle class are also found. These are built round a courtyard open to the sky, with a wooden balcony supported on columns of wood or brick, and rooms opening out of it (*see Fig.* 27). The roofs were flat or slightly sloped. On representations of towns there is often a tower at one end; a staircase led up to the living-rooms. The whole impression made by this early Sumerian civilisation is of magnificence in the case of the rulers and great officials, and of comfort among the middle classes.

The Sumerian people are represented in art as of a rather squat figure, with round heads and strangely projecting triangular noses, in strong contrast to the Semitic people who later became predominant in Mesopotamia. They usually are clean-shaven both as to hair and as to beard; but some early princes wear long hair and beard treated in the manner familiar in Assyrian statues, which evidently follow after a long interval the same fashion. Circumstances do not allow the same vivid pictures of their life as we find in Egypt. They seem mostly to have lived in towns with massive walls, for protection against enemies and floods. Some dynasties are recorded as already existing before the great flood, of which various traditions are preserved. Probably the common people, especially if occupied as herdsmen or agriculturalists, lived in temporary shelters in the plain.



•Fig. 27.—SUMERIAN HOUSE

After drawings by the late F. G. Newton

Exploration and excavation still continue, and there still appears to be an ample scope for their activities. The most promising sites in Greece itself have been dug; but there is still the project of the excavation of the central part of Athens, at present occupied by part of the modern town. Crete appears inexhaustible; and many of the great and once flourishing cities of Asia Minor still await their turn.

The excavation of Pompeii continues, and that of Herculaneum has been resumed; in Rome itself, and in its port town of Ostia, new and important excavations are in progress.

Field work is still being carried out at many places in Great Britain, mainly on Roman sites. A new auxiliary is now at the disposal of the archæologist. Photographs taken from the air have given accurate surveys of many regions hitherto inaccessible, and have revealed the sites and even the plans of unknown towns. In many parts of England such photographs have shown roads and earthworks which are invisible to those who walk over the site. In this, as in many other ways, archæology may claim to be among the most progressive of studies.

RECENT AND CONTEMPORARY PHILOSOPHY

By

A. WOLF

SYNOPSIS

The differentiation of philosophy and science — The main departments of philosophy: ontology, epistemology, and axiology — The chief types of philosophy, and how to distinguish them.

Ontological Problems and Solutions: fluxionism and substantialism; substantival monism, dualism, and pluralism; uniform and multiform pluralism; attributive monism, dualism, and pluralism; absolute idealism, spiritual pluralism, materialism, energism, and neutral monism; tychism, necessitarianism, mechanism, vitalism, and emergent evolution; theism, deism, pantheism, and agnosticism; naturalism and supernaturalism.

Epistemological Problems and Solutions: gnosticism, scepticism, fictionism, and pragmatism; transcendentalism, idealism, theory of representative ideas, and realism; empiricism, positivism, rationalism, intuitionism, and mysticism.

Axiological Problems and Solutions: the nature and number of the ultimate values; their objective or subjective character.

The general character of recent and contemporary philosophy, and the classification of representative philosophers.

Materialism, energism, and positivism in Germany — Absolute idealism in England, France, Italy, and the United States — Spiritual pluralism in England and Russia — Neo-Transcendentalism (or neo-Kantianism and phenomenology) in Germany — Biotism, vitalism, pragmatism, instrumentalism, and fictionism in France, Germany, and the United States — Realism, emergent evolution, and fluxionism in England, South Africa, and the United States.

Retrospect — The present amicable relations between science, philosophy, and theology, and some possible dangers.

RECENT AND CONTEMPORARY PHILOSOPHY

I. THE DIFFERENTIATION OF PHILOSOPHY

The original union of philosophy and science inevitably became loosened, in the course of the centuries, by the sheer accumulation of knowledge. Imperceptibly a division of labour came increasingly into operation. Not only was philosophy differentiated from science, but science became differentiated into many sciences, and philosophy differentiated into a number of philosophical studies. Nevertheless, until the nineteenth century some sort of pretence was kept up that Knowledge was one whole, and that the sciences were just specialised branches of philosophy. In the course of the nineteenth century however, not only was this pretence dropped, but there emerged something like a definite antipathy between science and philosophy. This was largely due to some of the German idealists, whose extravagant incursions into the domain of science aroused the general resentment of men of science. Even in Scotland, where everybody is reputed to be a philosopher, a scientist like Lord Kelvin did not veil his contempt for a philosopher like Edward Caird, when both were teaching in Glasgow. This kind of hostility gradually disappeared. Quite a number of scientists have actually turned philosophers. And at the present time the incursions of men of science into the domain of philosophy threaten to become about as embarrassing as were the incursions of philosophers into the domain of science about a hundred years ago. At the moment, however, we are only concerned with the differentiation of philosophy into a number of separate departments or branches. Something must be said about these in order to make the study of recent and contemporary philosophy generally intelligible.

Philosophy has three main departments, namely, (1) Ontology, or the study of the ultimate nature of being or reality, (2) Epistemology, or theory of knowledge, or the study of the ultimate problems relating to the nature, validity, and limitations of human knowledge, and (3) Axiology, or the study of the ultimate nature, reality and significance of values (goodness and beauty). Sometimes Ontology (1) and Epistemology (2) are grouped together as Metaphysics; but sometimes the term Metaphysics is used less correctly as synonymous with Ontology only, or with Epistemology only. The two sub-departments of Axiology (3) are Ethics or Moral Philosophy, the study of the ultimate ideals and norms of conduct, and Æsthetics or the Philosophy of Beauty, the study of the ultimate ideals and norms of art. There are also other departments of philosophy. Of these, however, Logic as the study of the general conditions of valid reasoning is really a preliminary to all other studies, including philosophy.

Psychology, the study of mental life, has recently established itself as an independent science. Lastly, such studies as those designated the Philosophy of Law, the Philosophy of the State, etc., are rather specialised studies arising out of certain ultimate problems of Law, Politics, etc., and intimately connected with these special departments of research. The departments of philosophy which are of most general interest are Ontology, Epistemology, and Axiology. And of these the first is of central interest, the other two are mainly of interest in so far as they help to throw light upon the first. In the following account attention will be paid chiefly to the ontological character of the philosophies dealt with, but the other aspects will also receive some consideration. Some philosophers, indeed, have confined their attention to the problems of epistemology. Of these only very few can be dealt with. And nothing at all can be said here about the numerous thinkers who are dealing with specialised philosophical problems. Important as their work is, it cannot be presented in a manner sufficiently intelligible and interesting to the general reader. Nor is it possible to include in this survey all the particular varieties of what is essentially the same world-view. Hence the inevitable omission of a number of well-known, and deservedly well-known, names in contemporary philosophy. However, this account actually deals with some forty representative philosophers, and future historians of philosophy will probably consider this a generous allowance for the period under review.

II. TYPES OF PHILOSOPHY

There are many different types of philosophy, and the tendency to refer to all of them by means of a few names is rather misleading. No doubt there are some advantages in limiting the number of main distinctions between philosophical systems. But it is important to have some appreciation not only of the principal cleavages between the various philosophies, but also of the specific differences between philosophies within the same group. Perhaps the simplest way to make all the more important distinctions sufficiently clear is to indicate briefly the chief problems which philosophers have to face, and also the different ways in which each of these problems has been answered in recent and contemporary philosophy.

(*a*) *Ontological Problems and Solutions*

(1) Perhaps the first philosophical question raised in the history of Western thought was this : Is there anything permanent at the basis of the changing phenomena of nature ? Many philosophers of all times answered the question in the affirmative, maintaining that there is some kind of " substance " underlying the flux of events ; others declined to admit any reality other than the flux of events as such. At the present time, largely under the influence of recent physical theory, a philosophy of events is perhaps accepted more widely than is a philosophy of substance. The difference between the two views may be expressed by means of the terms *ontological fluxionism* and *ontological substantialism.*

(2) The second question may be stated thus : Is there only one ultimate reality, or are there two or more ultimate realities ? The possible answers to this are obvious. Some hold that there is only one ultimate reality ; some believe in two ultimate realities ; others admit a multiplicity of ultimate realities. These different views are known as *substantival monism, substantival dualism*, and *substantival pluralism* respectively. Of the three, the first and last are the most widespread.

(3) The third problem is this : Is ultimate reality all of one kind only ? For those who accept *substantival monism* the answer is obviously in the affirmative. But for those who maintain a *substantival pluralism* the answer may or may not be in the affirmative. Some, for instance, believe in a plurality of spirits which are all essentially the same in kind, and deny the reality of anything else. Others believe in a plurality of atoms which are all essentially similar, and deny the ultimate reality of anything else. Either of these views may be described as *uniform pluralism*. Others, again, believe in a plurality of different kinds of ultimate realities (bodies, souls, etc.). This view may be described as *multiform pluralism*. Substantival monism, of course, is necessarily uniform.

(4) The fourth question is : How many fundamental (or irreducible) attributes does ultimate reality (or do the ultimate realities) possess ? The answer obviously may be, " One," or " More than one." The former view may be called *attributive monism*, the latter *attributive pluralism*. If the number of irreducible attributes is held to be two, then we may use the special name *attributive dualism*. Each of these distinctions naturally leads to other distinctions according to the irreducible attribute or attributes ascribed to ultimate reality. If it is held that the sole attribute is of the nature of mind or consciousness, the view is called *idealism* or *mentalism* or *spiritualism* ; if the sole attribute is identified more especially with thought, we get *panlogism* ; if it is identified with will, we get *voluntarism*. Idealists who accept substantival monism are called *absolute idealists* ; those who accept substantival pluralism are usually known as *spiritual pluralists* or *monadists*. The view which identifies the sole attribute with matter is called *materialism* ; the view which identifies it with energy is called *energism* ; the view which identifies it with something different from mentality or materiality, though underlying both these, is called *neutralism* or *neutral monism*.

(5) The next ontological problem is : How are the various parts, units or modes of reality interrelated ? One extreme view is that there are no real connections between things or events, that everything is a matter of chance. This view is known as *tychism*. Opposed to it is the view, known as *necessitarianism*, according to which law and order prevail throughout the universe, so that nothing really happens by mere chance. A special form of this view, and frequently but wrongly confused with it, is the view that everything happens in a way causally determined according to the laws of matter and motion. This view is variously described as *mechanism, determinism*, and *the mechanistic theory*. Midway between the two extremes of mechanism and tychism (yet presumably without flouting the various known and unknown types of orderliness maintained by necessitarianism) there are various views which aim at vindicating some measure of spontaneity, novelty or originality for natural events, and

freedom for man. These views are known variously as *vitalism*, *creative evolution*, *emergent evolution*, and, more rarely, *libertarianism*. *Teleology* is the view which more especially seeks to vindicate the reality of purposes or purposiveness in natural events, as against the mechanistic view that all is causally pre-determined, or against certain idealistic views which regard ultimate reality as a " block-universe " which is eternal and immutable.

(6) Another ontological question amounts to this : Is there any being, or anything, that may be called divine ? One answer is to the effect that we do not know. This view is known as *agnosticism*. The view which answers the question definitely in the negative is called *atheism*, a term rather liberally applied according to taste, or want of taste. Of the affirmative answers to the question the most familiar are those known as *theism*, *deism*, and *pantheism*, respectively. Theism is the belief in a personal God, who is the creator of nature and man, distinct from both, yet intimately connected with both. Deism and pantheism strive to avoid the anthropomorphic tendencies of theism, and insist that God is suprapersonal. Pantheism identifies God with the Universe, and thereby achieves a scientific economy.

(7) Lastly, there is this problem (more especially for those who recognise the reality of a divine being) : Is the world of reality one interconnected and orderly cosmic system, or is there a supernatural world, over and above nature, and capable of interfering with the order of nature ? This problem will probably be dismissed by agnostics and atheists as meaningless, inasmuch as they do not admit any other reality than nature. It will also be dismissed by certain idealists on the ground that there is no such thing as physical nature, and by certain other idealists who are definitely atheistic. Theism and deism, however, would both admit *supernaturalism*, though deism would reject miraculous interferences with the natural order of things. Pantheism definitely identifies nature or the universe with God, and so rejects the supernatural. And some forms of realism, while admitting the existence of deity in the universe, identify deity with part of the universe, and reject the supernatural. Such a rejection of a supernatural world, on the ground that the whole of reality is one orderly interconnected system, is known as *naturalism*. This term should not be confused, as it commonly is confused, with *materialism*. For naturalism leaves room for the mental, the spiritual, and the divine, whereas materialism (in the strict sense of the term) does not.

(*b*) *Epistemological Problems and Solutions*

(1) The first question relating to so-called human knowledge is : Do we have any real knowledge at all ? *Scepticism* is the view which throws doubt on the possibility of real knowledge. (Epistemological scepticism must be distinguished from the limited scepticism and agnosticism which only doubt or deny the possibility of knowledge of ultimate reality, or of God.) *Fictionism* mainly differs from scepticism in maintaining that the limitations of human knowledge are not peculiar to man, but characterise also the knowledge of superhuman minds, if there are such. *Pragmatism* likewise is not essentially different from scepticism. What it

says in effect is that the proper distinction is between fruitful beliefs and misleading beliefs, rather than between true and false beliefs, but fruitful beliefs may be called true, and misleading beliefs may be described as false. Fictionism, as compared with pragmatism, admits rather more candidly that even avowedly false views may have practical importance, and that it is just this practical importance that really matters. The view that knowledge is possible may be described as *gnosticism*. This term, however, is rarely used in philosophy. For gnosticism also has several varieties according to the different answers given to the next question, and so the names usually employed are the specific names of these varieties.

(2) The second question, which of course does not concern the several forms of scepticism, is this : How are the cognitive experiences, by which we know objects, related to these objects, or *vice versa* how are the objects known related to the cognitions ? *Transcendentalism* maintains that some unknown materials are given to us but that the mind in the very act of apprehending them gives them certain forms, such as order in time and space, causal connections, etc. (This view is also known as " criticism " or " critical idealism "). According to *ontological idealism* all objects are mental in character, and their very existence is dependent upon some apprehending mind or knowing subject, though this need not be the finite mind of man, but the Absolute, or " consciousness in general." According to the *theory of representative ideas* there are two kinds of objects, namely, psychical objects (or ideas), which depend on the mind and are directly revealed to it, and physical objects, which are independent of mind and are revealed to it only indirectly, or inferentially, through mediating experiences. Lastly, according to *realism*, objects exist quite independently of their being cognised, and are apprehended directly by the mind, and as they are, more or less. Of these views, realism probably commands the largest following. There are, however, so many varieties of realism that it is impossible to deal with them here.

(3) A third epistemological problem concerns the avenues of knowledge. There are at least three such avenues commonly recognised, more or less. But there are great differences of emphasis ; some thinkers emphasise one of these avenues, others another. *Empiricism* stresses sense-experience as the chief source of real knowledge. *Positivism* treats experience as the only source of knowledge, and is consequently opposed to all metaphysical speculation. *Rationalism* emphasises the supreme importance of reason and of reasoning from, and according to, general principles. *Intuitionism* attaches the greatest value to intuition, which is regarded as a more primitive form of apprehension, prompted largely by feelings and instincts, and not yet so intellectual and abstract as thought and perception are. In recent philosophy intuitionism has come into great prominence. Lastly, *mysticism* upholds the possibility of an indescribable spiritual vision of deity or of ultimate reality. It should be noted that the supporters of one of the latter views often allow relative validity to other powers of apprehension than the one to which they chiefly pin their faith. This is usually done by the recognition of different grades of knowledge. In this way, a mystic may allow *some* value to intuition, reason, and even sense-perception ; an intuitionist, to reason and sense-perception, and so on.

(c) *Axiological Problems and Solutions*

When we are interested in anything we attribute value (or worth) to it. Things are valued very differently, of course. Many things, perhaps most things, are valued only as a means to an end. But there are some things that are valued for their own sake. These may be called *ultimate values*; and in philosophy we are mainly concerned with such ultimate values.

(1) The first axiological problem is: How many and what ultimate values are there? The usual answer is that there are three such ultimate values, namely, Beauty, Goodness, and Truth. To these three a fourth is sometimes added, namely, Worshipfulness, or religious value. But most thinkers are probably of opinion that religion is concerned with the conservation of the first three ultimate values mentioned above, rather than with the apprehension of any additional value. There are also other views which need not be discussed here.

(2) The second, and most important, axiological question (and the only other question that can be referred to here) is this: How are the ultimate values related to reality? Do they belong to things in the same kind of objective way as the primary qualities do, or are they as subjective as secondary qualities were usually considered to be? Some who regard secondary qualities (colour, scent, taste, etc.) as subjective tend to think that values (or tertiary qualities, as they are often called) are also subjective. According to this view, then, values are merely psychological characters which are attributed to things in virtue of somebody's interest in them, but have no reality apart from such interest or appreciation. Some hold that values are, at all events, independent of finite, individual selves. Others, admitting the objective reality of secondary qualities, have no difficulty in admitting also the objective reality of values. Still others, indeed, regard values as of the very essence of reality, and speak confidently of a kind of mystic experience (intuition or vision) in which reality and value are apprehended as one. Lastly, there are various differences of opinion as to which of the above-mentioned ultimate values are objective. Some have no difficulty in regarding beauty as an objective quality of a beautiful landscape, or in regarding goodness as an objective quality of a good action or a good character, but cannot attribute truth to anything but propositions. Others find it easier to accept the objectivity of Truth than of Beauty or of Goodness. And so on. In the main, however, it may be said that the present tendency is to treat ultimate values as objective rather than as subjective, although there are different views as to the precise sense in which their objectivity should be interpreted.

(d) *The Characterisation of Types of Philosophy*

This brief review of philosophical problems and their solutions may suffice to show that no philosophy can be adequately described by means of any single "ism," like "monism," "idealism," "realism," etc. A considerable number of "isms" would be required in order to characterise correctly any one system of philosophy. And an exhaustive classification of the possible combinations of the various "isms" would be a very complex affair. Any such attempt, moreover, would be hampered also by the fact that the antitheses between different views have lost a

good deal of their sharpness, in recent years, owing to an increase in mutual understanding and a consequent " meeting of extremes," which makes it necessary to take into account differences of shade and of emphasis as well as the more palpable differences. Then, too, there is, in the last resort, something individual and personal about each philosophy, and this complicates still further any attempt at an accurate classification. Yet, for the purpose of an easy survey, any grouping is better than none, and there are certain advantages in a simple grouping, provided it is not misunderstood. We propose, therefore, to arrange the selected representatives of recent and contemporary philosophy in a few rather loose groups, trusting that the foregoing summary review of the main problems of philosophy and their solutions will enable the reader to put each philosopher in his proper place in the general philosophic scheme, if he so desire.

III. GENERAL CHARACTER OF RECENT AND CONTEMPORARY PHILOSOPHY

(*a*) The period with which we are concerned is a period of about half a century, beginning approximately at the point where the " Retrospect " (see the first Article in this volume) ends, and terminating early in 1931. The middle decades of the nineteenth century showed a marked tendency towards materialism and empiricism. This tendency gave rise, on the one hand, to a certain amount of philosophy which was more or less materialistic, or energistic, or at least positivist; but, on the other hand it also stimulated, by way of reaction, a strong interest in idealistic philosophy. Idealistic philosophy had had a golden age during the fifty years or so following the publication of Kant's *Critique of Pure Reason* (1781), and its traditions had been kept alive by at least a few distinguished philosophers. It was therefore comparatively easy to take up, and to develop, the idealistic philosophy in its various forms. The greatest service in this connection was rendered probably by T. H. Green, who developed his views, just as Kant had developed his, largely in opposition to the empiricism and scepticism of Hume. Of the several forms of idealism which have been taught during the period under review two at least may be readily distinguished, namely, absolute idealism (which tends to be pantheistic), and monadism or spiritual pluralism (which is usually, though not always, theistic).

In Germany, the revived interest in idealism produced a philosophic movement the aim of which was to begin all over again the work of transcendental criticism initiated by Kant. This movement began with the slogan, " Back to Kant," but eventually, although it tried to be even more radical than Kant, it ended by being far more speculative, and perhaps less critical, than he had been. Of this movement, which may be called Neo-Transcendentalism, or critical idealism, there are at least three branches, namely, one led by H. Cohen, another by W. Windelband, and a third by E. Husserl. The first two of these are commonly known as Neo-Kantianism, the third as Phenomenology.

Idealism has taken firm root not only in England and Germany but also in France, Italy, and the United States of America.

In France the reaction against materialism assumed yet another form than that of idealism, though intimately connected with it historically. H. Bergson, namely, has expounded a philosophy according to which ultimate reality is Life (rather than the "matter" of materialists or the "thought" or "consciousness" of idealists). For want of a better word this philosophy may be named "biotism." The concept of evolution naturally has an important place in biotism. In Germany and elsewhere a somewhat similar reaction to materialism has shown itself in the much more restricted view known as "vitalism," the view namely that living organisms cannot be explained without assuming a principle of life (or vital principle) as dominating the physical organism. Various theories of knowledge have also been influenced by "biotism." This applies notably to certain epistemological theories already mentioned, namely, pragmatism, instrumentalism, and fictionism, all which treat beliefs as instruments of life, and to be valued accordingly.

While idealism may be said to have succeeded very well in its opposition to materialism, and as a reaction against this, it has also managed to provoke a reaction against itself. Some thinkers, while agreeing that it is impossible to derive mind from matter, find it equally difficult to derive matter from mind, or to regard matter as in some sense an external appearance of mind. In recent years this reaction against idealism has been based mainly on epistemological considerations. The anti-idealistic view is known as realism, of which there are various kinds. But they are most of them agreed in maintaining the reality of something besides mind (or consciousness) and independently of it. Some realists have developed a more or less complete system of philosophy, while others have so far confined their attention to the epistemological problems. For the most part realists are also naturalistic, and some of them find room for deity within the universe.

One of the most characteristic features of recent philosophy is due to the influence of the new physics. The tendency of recent physicists to regard matter as composed, in the last resort, of electric charges or waves has induced some philosophers, especially the realists, to conceive reality as fluxional rather than as substantival, that is to say, as consisting of a flux of events rather than of permanent substances. This view, which has already been described as fluxionism, has probably had a good deal to do with the abandonment of naturalism on the part of many contemporary scientists, and their almost embarrassing anxiety to subscribe to idealism. Some appear to be acquainted only with the following short catechism :

Q.—What is mind ?	A.—No matter.
Q.—What is matter ?	A.—Never mind.

Difficulties in the conception of matter, however, are a poor reason for identifying it with mind. Some try to get over the difficulty by positing some third kind of entity which is neither mind nor matter but from which both have emerged. This "neutral stuff" is sometimes called "mind-stuff," apparently because it is neither "mind" nor "stuff," though it gives rise to both.

Another characteristic feature of recent philosophy is the emphasis

placed upon emergent evolution. This is especially true of biotism, for which life and its creative evolution are almost everything. But it is also true of realism. This is due partly to the tendency of realism to base itself as far as possible on the broad results of science, biological as well as physical; and evolution is, of course, one of the basic theories of modern biology. And partly this is due to the tendency of realism towards naturalism, and the help which the concept of emergent evolution affords in the attempt to include all realities in the one universe.

(*b*) In accordance with the foregoing sketch of the main tendencies in recent and contemporary philosophy we propose to arrange the following accounts of some forty representative philosophers of the period under the following headings:—(1) materialism, energism, and positivism; (2) absolute idealism; (3) monadism or spiritual pluralism; (4) neo-transcendentalism (or neo-Kantianism and phenomenology); (5) biotism, vitalism, pragmatism, instrumentalism, and fictionism; (6) realism, emergent evolution, and fluxionism. The general significance of these terms has already been explained in the preceding pages.

The selection of representative philosophers is always a difficult matter for a contemporary, especially when there is an *embarras de richesses*. Many fishes as good have been left in the sea. Moreover, the different countries have been treated very unevenly, and their philosophical merits must not be judged by the number of their representatives included in the following sketches. The selection of representative philosophers has been determined mainly by the desire to have every important philosophical tendency adequately represented, and to have them represented, as far as possible, by philosophers in whom English and American readers of general education are likely to be most interested. To these considerations must probably be added another factor, namely, the writer's convenience and limitations.

IV. MATERIALISM, ENERGISM AND POSITIVISM IN GERMANY

E. H. Haeckel (1834–1919) was probably the most influential advocate of Darwinism. In his hands Evolutionism became a whole system of philosophy instead of a purely biological theory. Of the biological ideas associated with his name the most familiar (though he did not originate them entirely) are those of phylogeny and recapitulation. Phylogeny is the study of the evolution of the various species of plants and animals. It leads to the construction of genealogical trees, the lower parts of which represent the ancestral types, while the branches represent various descendants, and the twigs represent the latest offspring. In his *Descent of Man* Darwin had already sketched one such tree. Haeckel and his followers attempted many such genealogical trees. The principle followed was briefly this. First of all it was determined by comparison what animals had a similar form or plan. For example, the amœba and infusorians are alike in being unicellular. Next, we note which of them is the less differentiated. This is regarded as the ancestor, or as the type nearest to the ancestral form of that group. Thus, for instance, the amœba has no definite organs, whereas the infusorians have certain specialised structures. The amœba was, accordingly, regarded as the ancestor, and the

infusorians as a branch. The other theory, namely, the Recapitulation Theory, states that during its development, from the egg to its final form, every animal repeats the stages in the evolution of its species from its unicellular ancestor. The pace of embryonic development is, of course, enormously faster than that of the racial evolution. In the course of a few days, or even a few hours, an embryo may pass through a number of stages which may have taken millions of years in the racial evolution.

According to Haeckel the simplest conceivable animals, the so-called *moneras*, crystallised from lifeless matter. And he conceived of the whole cosmic process as a continuous evolution, from the simplest atoms to the highest forms of being, in accordance with strictly deterministic laws. There is no fundamental difference between living and lifeless bodies, for lifeless crystals have definite structures whereas some living organisms have none. Moreover the elements found in organic matter are also found in inorganic matter, and it is possible to produce some organic compounds artificially. All things, then, are composed of the same kinds of elements, and are dominated by the same forces of attraction and repulsion between their atoms. Even the so-called soul is only a number of extremely complex reactions of the central nervous system. The simplest living things arose by spontaneous generation, and from these all higher forms of life have evolved under Natural Selection. A molecule more or less of carbon or phosphorus or sulphur may have been the sole difference between the primitive forms of life which formed the several ancestors of all the many forms which have evolved from them. Haeckel stressed the *monistic* character of his world-view, inasmuch as he held that matter (composed of atoms) is the only ultimate reality, and that all things, living as well as lifeless, conscious as well as unconscious, have evolved from it according to iron laws. His monism, in fact, looks very like materialism. Yet that is not altogether true. For he endowed even his atoms with souls, so that matter, as Haeckel conceived it, was not the lifeless matter of thoroughgoing materialists. Haeckel was a hylozoist rather than a materialist. And Haeckel's philosophy, if it was monistic as regards the one ultimate substance which he recognised, was also dualistic in regard to the two attributes (materiality and mentality) with which he credited it. Force was regarded by Haeckel as an aspect of matter.

[*Natürliche Schöpfungsgeschichte*, 1868 (Eng. Tr. *The History of Creation*, London, 1883);
Anthropogenie, 1874 (Eng. Tr. *The Evolution of Man*, London, 1879);
Die Welträtsel, 1899 (Eng. Tr. *The Riddle of the Universe*, London, 1902).]

W. Ostwald (b. 1853) has formulated a philosophy of "energetics," according to which ultimate reality is energy. Energy is capacity for work, or what results from work, or what is converted into work. All the properties of matter can be expressed as various forms of energy. Its mass can be expressed in terms of work and velocity. Its volume can be expressed in terms of compressibility. Its shape can be expressed in terms of elasticity. And matter is just the synthesis of such energies. Heat, light, sound, magnetism and electricity are all of them kinds of energy. All

chemical properties are forms of energy which operate in the transformation of substances. Bodies are comparatively stable collocations of various energies in approximate equilibrium. Living organisms are stationary bodies having free chemical energy to render metabolism, nutrition, and reproduction possible. "The entire mechanism of life can be compared to a water-wheel. The free energy corresponds to the water, which must flow in one direction through the wheel in order to provide it with the necessary amount of work. The chemical elements of the organisms correspond to the wheel, which constantly turns in a circle as it transfers the energy of the falling water to the individual parts of the machine." Consciousness likewise is some kind of energy. Ostwald speaks of soul-energy as well as nerve-energy. "We know that mental work is connected with an expenditure of energy and exhaustion, just as physical work is." Ostwald repudiates the charge of materialism, seeing that he rejects the ultimate reality of matter altogether. He has also protested against the common assumption that he meant to reduce life and consciousness to merely physical energy. His view is rather that while so-called physical energy must be regarded as the basis of all things, including life and consciousness, yet some sort of auxiliary concepts are required to account for the appearance of life and of consciousness. What he has in mind is the kind of concepts after which vitalism and emergent evolution are feeling their way, though he does not accept vitalism as such. With regard to his reduction of matter to energy, Ostwald claims in his favour the whole tendency of recent physics to reduce atoms to electric charges.

[*Die Überwindung des wissenschaftlichen Materialismus*, 1895; *Naturphilosophie*, 1902 (Eng. Tr. *Natural Philosophy*, London, 1911); *Die Philosophie der Werte*, 1913.]

E. Mach (1838–1916) maintained that the physical and mental sciences should apply the same scientific methods, inasmuch as the subject-matter with which they are concerned is reducible to common terms. Following out the line of argument used by Hume, Mach argued that physical and psychical phenomena can be resolved into common elements. For, by identifying physical objects with their sensible appearances, Mach thought that he abolished the alleged intrinsic differences between physical and psychical phenomena. The only difference between them, according to Mach, consists in their external relationship to other phenomena. The phenomenon of colour, for instance, is physical in relation to its luminous source; it is psychical in relation to the experience of sensing it; but in itself it is neither physical nor psychical. The relationship in question is what is commonly known as dependence, and is determined usually either by the method of difference or by the method of concomitant variations, the successful application of which establishes a functional relationship between various contents of experience. The main aim of science is to discover such functional relations between phenomena. Such discoveries, when crystallised in ideas and theories, serve an economic purpose, inasmuch as they summarise past experiences and anticipate future experiences. That, in fact, is the motive which prompts our search

for such ideas and theories. It is the felt need of finding our way in nature that necessitates the discovery of such concise directions for the conduct of life. The tendency of science to replace qualitative by quantitative accounts of phenomena is due to the greater simplicity and comprehensiveness (that is, economy) of quantitative summaries. Ultimate reality, according to Mach, is almost what is now commonly called "neutral stuff," and Mach's philosophy was substantially monistic. But he was explicit in his rejection of materialism. Bodies were for him only thought-symbols of complex experiences. And the extensive use of "mechanistic" modes of explanation he regarded as due to our greater familiarity with them, and to the tendency to employ analogies in order to simplify explanation. Even what is explained mechanistically must, therefore, not be regarded as though it were merely mechanical or material. His conception of the rôle of science, and of knowledge generally, was influenced by the theory of evolution and its emphasis on the need of a growing adaptation of life to environment in order to ensure survival.

[*Die Mechanik in ihrer Entwicklung*, 1883 (Eng. Tr. *The Science of Mechanics*, London and New York, 1893);
Beiträge zur Analyse der Empfindungen, 1886 (Eng. Tr. *The Analysis of Sensations*, London and New York, 1906);
Erkenntnis und Irrtum, 1905.]

V. ABSOLUTE IDEALISM IN ENGLAND, FRANCE, ITALY, AND THE UNITED STATES

T. H. Green (1836–1882) was the leader of the English idealist reaction against empiricism and evolutionism. Negatively his philosophy was prompted by his aversion for what used to be regarded as typically British philosophy. Positively it was influenced by German idealism, and is consequently described sometimes as Neo-Kantianism or Neo-Hegelianism. His hostility to empiricism (as taught by Hume and his followers) and to evolutionism (as taught by H. Spencer and others) was inspired, in the first instance, by moral considerations. He felt that when man is conceived to be a "being who is simply the result of natural forces," his character is misunderstood and his life is degraded. Such a conception, according to Green, utterly fails to account for man's sense of moral obligation, involves a denial of human personality and of the very possibility of all the higher intellectual and moral activities of man. Green accordingly set out to show the true nature of man, his real potentialities, and his relation to merely natural phenomena.

In order to understand the real nature of man it is necessary first of all to understand the nature of our consciousness, the reality of which is all that we are sure of, to begin with. Now human consciousness, according to Green, is essentially self-consciousness. In the case of man even the simplest process of sense-perception is not a mere change, but the consciousness of a change. All human experiences, in short, consist not of mere events, physical or mental, but of *recognitions* of such events. What we apprehend, therefore, is never a *bare* fact, but a *recognised* fact, a synthesis of relations in a consciousness which involves a *self* as well as

the elements of the objects apprehended, which it holds together in the unity of the act of perception. Thus knowledge always implies the work of the mind or self. This work of the mind, however, is not capricious or arbitrary. This is attested both by the common distinction between truth and error, between reality and illusion, and by the very existence of the sciences. But all this, according to Green, implies that the reality which we know is an intelligible reality, an ideal system, in short, a spiritual world. And such a world can only be explained by reference to a spiritual " principle which renders all relations possible and is itself determined by none of them," an absolute and eternal self-consciousness which apprehends as a whole what man only knows in part. This " principle," this absolute and eternal self-consciousness, is God. In some measure man partakes of the self-consciousness of God. This participation is the source of morality and religion. It is also the justification of the belief in immortality. For a self-conscious personality cannot be supposed to pass away but must partake of the nature of the eternal.

Turning to the moral life of man, Green maintains that reflection reveals to man certain capacities and corresponding responsibilities, in the exercise of which man finds his highest good. This good consists in the realisation of personal character, the realisation of the highest self. In so far as the motive which prompts one to realise one's true or highest self lies in man himself, the determination so to realise one's self is a self-determination. And such self-determination to realise his true good constitutes the freedom of man. But individual self-realisation is possible only in society. Just as there can be no society without individual persons so there can be no fully developed persons without a society in which the individual persons, while retaining each his own individuality, are also integrated so as to form a social whole, in which each develops his special aptitudes. It is only in such a society that the highest moral good can be realised.

[*Prolegomena to Ethics*, Oxford, 1883; *Works* in 3 vols., London, 1888.]

F. H. Bradley (1846–1924) attempted to construct an idealist philosophy free from that intellectual bias which characterised Green's idealism. Of the moderns, it was Hegel who had first identified the " real " with the rational, and Green had adopted the same view. Bradley, however, found this kind of idealism " as cold and ghostlike as the dreariest materialism." The apparent glory of the perceived world is just as much " a deception and a cheat " if it hides some " spectral woof of impalpable abstractions, or unearthly ballet of bloodless categories " (which Hegelian idealism regarded as ultimate reality) as if it hides " some colourless movement of atoms " (which materialism treated as ultimate reality). Apparently the nature of consciousness, which Green had made the starting-point of his philosophy, had not been fully appreciated by him. Bradley, accordingly, made a fresh start.

For Bradley the starting-point is " immediate experience " rather than cognitive consciousness. In immediate experience we have " an immediate feeling, a knowing and being in one." It is at first an undifferentiated unity, and non-relational, but it contains implicitly numerous distinctions

which discursive thought or judgment makes explicit. For immediate experience is felt to be inadequate, and thought is our endeavour to supplement it by introducing distinctions, abstractions, qualifications, and relations, etc. But the categories and concepts with which thought operates, though useful as working ideas for the special tasks of science, are unsatisfactory for a philosophic understanding of ultimate reality. " The Nature studied by the observer and by the poet and painter, is in all its sensible and emotional fulness a very real Nature. It is in most respects more real than the strict object of physical science." For the concepts of science are abstract and not ultimately true. Space and time, relation and quality, primary and secondary qualities, motion and change, causation and activity, self and things-in-themselves—all these notions when closely examined end in self-contradiction, and are therefore applicable only to mere " appearances," not to ultimate reality. For ultimate reality must be self-consistent and harmonious. Yet even " appearances " cannot be mere illusions, though Bradley sometimes described them as such. They must have a place in ultimate reality. How is ultimate reality, the Absolute, to be conceived ? The clue to such a conception, though a very inadequate conception, is sought by Bradley in immediate experience, at least in immediate experience at a higher remove. The Absolute is a Spirit embracing and completing all finite experiences and " appearances." And the experience of the Absolute, or the absolute experience, repeats at a higher remove, with infinitely greater wealth and perfection, the " immediate feeling," the " knowing and being in one " which characterises the " immediate experience " of human beings. " Reality is one experience," and " experience " exhausts all reality. " There is no being or fact outside of that which is commonly called psychical existence. Feeling, thought and volition (any groups under which we class psychical phenomena) are all the material of existence. And there is no other material actual or even possible." " Spirit is the unity of the manifold in which the externality of the manifold has utterly ceased." " Outside of spirit there is not, and there cannot be, any reality, and the more that anything is spiritual, so much the more is it veritably real."

Unlike Green, who believed in the *personality* of God, Bradley regarded the Absolute as supra-personal. He also rejected the attribution of " goodness " to God. And he denied the view (of Kant and Green) that personal immortality is an implication or postulate of the moral life. But, in agreement with Green, Bradley denied evolution of the Absolute. The Absolute " has no history of its own, though it contains histories without number."

thought leads by its abstractions. Bosanquet maintained that it was a misconception of the real nature of thought to identify it with the formation of abstract universals, which naturally led to an inadequate interpretation of reality. Thought at its best is systemic, not merely abstract. It helps us to construe the systematic character of reality. Its characteristic " universal " for the understanding of reality is the " concrete universal," that is, the conception of a " whole " or " system," not the merely " abstract " universal which is only concerned with what is common or general in things, instead of with their systemic interrelations in a whole or system. So conceived, thought leads, not to contradiction or illusory appearance, but to the very heart of reality. In fact it is " the self-revelation of reality." Thought and reality are correlative. " Thought . . . is always an affirmation about reality." And reality " is the whole that thought is always endeavouring to affirm." The common opposition of thought (or logic) to feeling struck Bosanquet as the silliest of all silly superficialities. " The emotional absorbing or carrying power which belongs to great ideas, great characters, great works of art, is measured by the depth and spread of their roots and sources in reality ; and this again is measured by their logical power, their power to develop and sustain coherence with the whole." In all experience the influence of " the whole," or the concrete universal, is implicit. But in logical thought, which follows the natural impulse to seek truth and reality, we have " the whole " operating explicitly as the criterion. In it " the idea of system, the spirit of the concrete universal, in other words, of individuality, is the central essence." All higher human experiences are characterised by the fact that in them comes to light the coherence of things, the " wholeness," or systemic integrity, of the universe, that is, the Absolute. In such experiences, accordingly, we feel " the heart-beat of the Absolute." And the Absolute is the final synthesis of mind and nature. Nature and mind are correlative. Nature is what is revealed to mind ; and mind is what apprehends or interprets nature. In the Absolute all finite experiences are transmuted and perfected into a complete whole. As such a Whole in which everything is adjusted in relation to the rest, the Absolute may be described as teleological or self-directing.

[*Knowledge and Reality*, London, 1885 ;
Logic, Oxford, 1888, 2nd edn. 1911 ;
Principle of Individuality and Value, London, 1912 ;
Value and Destiny of the Individual, London, 1913 ;
Implication and Linear Inference, London, 1920 ;
Meeting of Extremes in Contemporary Philosophy, London, 1921.]

Viscount Haldane is essentially a follower of Hegelian or Absolute Idealism, though ... ... not like the term idealism. Experience is the only possible point of departure. But experience always discloses as immanent in it, and as its foundation, an ideal system wider in range and in quality than itself. This ideal system Haldane calls " Knowledge." But this " knowledge " must not be regarded as merely an object of our experience, or as an activity which merely establishes external relations of independent objects to the mind. The character of an object is never

independent of the character and activity of knowledge. For being always implies meaning of a certain kind; to be meaningless is to be beingless. There are many different levels of knowledge varying with the extent to which abstraction is made from the wealth of detail in the facts observed; and each level of knowledge has for its object a corresponding level of reality. Physics, Biology, and Psychology, for instance, involve diminishing degrees of abstraction, and accordingly represent different levels of knowledge and reality. But all levels of knowledge and reality have their places and mutual relations in the entire system of Knowledge. The truth is the whole, but the limitations of finite minds, and their habit of distinguishing subject from object, prevent them from grasping the whole fully. Perfect knowledge must, however, be conceived as self-complete and all-inclusive. In it the isolation of subject from object, and the antithesis of universal and particular, are overcome. Unlike human experience, all that is distinguished in it falls within it, so that it is more than merely relational; it is an absolute system of self-knowledge. The conception of such ideal knowledge and of its immanence in human experience seems necessary for the understanding of the Universe. Knowledge interpreted in this wide sense, and with its ideal completion taken into account, is not only the foundation of reality, but is indistinguishable from it. In other words, Knowledge is not merely one kind of event among others; it is the universe which embraces all events.

[*The Pathway to Reality*, London, 1903;
The Reign of Relativity, London, 1921;
The Philosophy of Humanism, London, 1922.]

F. Ravaisson-Mollien (1813-1900) helped to revive and develop the philosophy of spiritual activity initiated in France by Maine de Biran (1766-1824), but long neglected. According to Ravaisson, nature is essentially spirit or spiritual activity. Spiritual activity is not merely a function or attribute of reality, but reality itself—to act is to be, and to be is to act. Thought is such a spiritual activity, for volition and thought are one and the same activity. The aim of thought is the unification of experience. And knowledge is essentially like art, since knowledge is the product of the creative synthesis of thought. Knowledge of reality is impossible without the aid of spiritual categories. The biological sciences, as C. Bernard (1813-1878) had shown, had to explain the parts of organisms by reference to the whole, and could not dispense with teleological explanation. But the physical sciences are not essentially different in this respect, since inorganic or inanimate phenomena differ only in degree, not in kind, from those of life and consciousness. The inertia characteristic of inanimate objects is a kind of habit, or a degeneration of will, and only spirits are capable of forming habits. Physical nature is a by-product of God, a " dispersion " of the divine spirit. God is the supreme principle of order and harmony in the world. He created matter, with all its imperfections, in order that life may re-awaken out of it and so recover its perfection. Progress presupposes a fall.

[*Rapport sur la Philosophie en France au XIX Siècle*, 1867 (5th edn. 1904);
De l'Habitude, 1894.]

C. Renouvier (1815–1903) attempted a fusion of positivism and idealism on a basis of phenomenalism. Phenomena, he insisted, are the only things directly known. They are our data. Now phenomena have two aspects. They appear *to* us, and they are appearances *of* something. It is a mistake to divorce either of these two aspects from the other. That is to say, it is a mistake to treat phenomena as if they were objects independent of all experience, independent of their appearance *to* somebody—this is the realistic mistake; and it is a mistake to treat phenomena as if they were just experiences without any objective reference, as if they were not appearances *of* something—this is the idealist's mistake. Phenomena must be regarded in their integrity, in their dual aspect. And regarded in this way they constitute reality, so that we can dispense with a thing-in-itself and with an independent subject beyond the experiences of the phenomena. This does not reduce the world to the mere play of subjective caprice, for phenomena have their laws, or uniform mutual relations, which give them order and permanence. In the first place, they all have certain ultimate laws or categories, namely, Relation, Number, Extent, Duration, Quality, Becoming, Causality, Teleology, and Personality. In the second place, they are subject to the various particular laws discovered by the several sciences. In his later writings, however, he admitted also the existence of more organic individualities than orderly aggregates of phenomena, namely, Leibnizian monads, spiritual individualities, and personalities. "When freedom makes its appearance in a given being, that being, bound by a thousand relations to other beings, acquires an incomparably more individual existence : what was only distinguished is now separated ; what was a self becomes self-subsistent, an essence, or . . . a substance . . . ; an individual, and the most individual individual that is known—the human individual, the human person."

Moreover, in order to form a comprehensive view of reality as a whole, more is needed than a knowledge of the categories and particular laws. We must assume the principle of contradiction, and we must resort to the principle of free Belief under the inspiration of our whole personality. Renouvier believed in a kind of harmony between man and the universe, in virtue of which the universe responds to the moral demands of man.

In some ways it would be better to class Renouvier's philosophy with critical idealism, or even with monadism, rather than with absolute idealism. On the whole, however, in a brief outline like this, it is better not to separate him from the other French idealists included here, namely, Ravaisson and Lachelier.

[*Essais de Critique générale*, 1854–1869, 2nd ed., 1875–1886 ;
La Nouvelle Monadologie, 1899 ;
Les Dilemmes de la Métaphysique pure, 1901 ;
Le Personalisme, 1903.]

J. Lachelier (1832–1918) set out from the critical philosophy of Kant. According to this philosophy the world of experience, as science interprets it, derives its orderliness or organisation from the forms and categories with which the mind apprehends and interprets it. And the natural laws discovered by science owe their universal validity to the fact that

they must conform to the constitution of the mind, inasmuch as they are products of the mind. Whereas, however, Kant had assumed that the mind only applied certain forms and categories to certain sense-data, or raw materials, independent of it, Lachelier maintained that mind actually creates the whole world of experience, and that there are no independent data to which it must adapt itself. In other words, according to Lachelier, mind or thought is the only ultimate reality. The world of sense-perception, it is true, appears to everybody to be independent of perception. But this is only so because that world is the object of an intelligent consciousness, which gives it objectivity by making it an object of thought, and thereby saves it from the mere subjectivity of sense-consciousness. It is just by organising them into a system of truths that thought gives objectivity to physical and mental phenomena and saves them from subjective relativity. And the reality of thought is demonstrated by the existence of a world which only thought can explain. The existence of sensibility shows that thought is something more than pure intellect. For it is by an act of will that thought gives a sense-content to space and time. Lachelier, in fact, distinguished three levels of thought. On the first level, thought is intellectual and abstract and treats things as subject to mechanical causality. On the second level, thought has particulars for its objects, which it posits by an act of will, and externalises in space. These objects are pictorial and determined teleologically. On the third level, thought is self-conscious, and attains its freedom. Lachelier associated these three levels with science, art, and religion respectively. The three levels, or grades, were not intended by him to represent three successive stages in time, but rather as co-existing phases. " Being is not first a blind necessity, then a will which must always be restrained by that necessity, and finally a freedom which must recognise the existence of both. It is freedom through and through, in so far as it is produced by itself; it is will through and through, in so far as it is something concrete and real; it is necessity through and through, in so far as it is intelligent and gives an account of itself." Lachelier identified God with universal Thought; and Religion with the individual's sense of dependence on universal Thought.

[*Du Fondament de l'Induction*, 1871;
Psychologie et Métaphysique (in the *Rev. de Métaph. et de Morale*), 1885.
Both in one volume in 1896.]

B. Croce (b. 1866) is the leading idealist philosopher of contemporary Italy. His " philosophy of the spirit " sets out from the Augustinian and Cartesian view that conscious experience is what we are most sure of; and he maintains, after the manner of the German idealists, that it is the only sort of reality that need be assumed. Spiritual reality, however, contains more than the experiences of merely finite minds. Like the absolute idealists, Croce posits also a universal consciousness or Spirit which is immanent in all finite minds and is more than the mere totality of finite minds. But whereas Hegel and his followers conceived of the dialectic of universal thought as essentially logical rather than temporal in character (though Hegel could not avoid conveying the impression that it was also a process in time), Croce definitely regards the cosmic spirit as a process in

time, and identifies reality (or philosophy, for the two are necessarily the same in such a spiritual system) with history. That is to say he regards reality as incessantly changing, always active, ever creative. Like Bergson and James he rejects the conception of a static, immutable Absolute, or "block universe" complete once for all. Cosmic activity proceeds in cycles, but is without a beginning and without an end. Within this total spiritual activity certain phases, aspects, or factors may be distinguished, though not separated. First of all its *theoretical* activity may be distinguished from its *practical* activity. And then within each of these it is possible to make two further distinctions. In the case of theoretical activity Croce distinguishes between *intuitions* and *concepts* (or thoughts or ideas). Intuition is the act of creating the materials of cognition, and is best exemplified in the creative vision of the artist. Here there is no sense material supplied to the mind from outside (as is commonly believed to be the case)—the mind just produces or creates its intuitions. Conceptual thinking operates on intuitions and traces relations between them, or traces what is universal in them. Actually the concepts are immanent in the intuitions, and the two can never be separated. Intuitions without concepts would be blind; concepts without intuitions would be empty. The concepts, however, have a certain special significance. They are common to all minds or spirits, and are the means of communion between them. They are universal, and are expressive of the universal Spirit that is immanent in all finite minds. As to the objects to which theoretical activity must always be directed, they also are the creations of that activity. In fact the process of thinking, the object of thought, and the discrimination between the activity and the object are all of them aspects of the same total experience. It is only by a process of abstraction that a world of seemingly independent objects is set up over against the world of thought. Turning next to practical activity, this is always volition, of course, since there are no physical actions in a spiritual world. Practical activity is dependent on theoretical activity, for volition depends on cognition. Croce distinguishes two kinds of practical activity, namely economic activity directed towards the useful, and moral activity directed towards the good. Economic activity is individual and egoistic; moral activity is universal and altruistic. But, like intuition and conception, economic and moral activity are not separate, but only distinguishable phases of the same whole, so that every practical action has at once an egoistic and a altruistic character.

[*Estetica*, 1902 (Eng. Tr. *Æsthetic*, London, 1909);
Logica, 1905 (Eng. Tr. *Logic*, London, 1917);
Filosofia della Pratica, 1909 (Eng. Tr. *Philosophy of the Practical*, London, 1913);
Storiografia, 1920 (Eng. Tr. *History*, London, 1921).]

G. Gentile (b. 1875) approaches philosophy from the standpoint of education, which he regards as a process of self-development culminating in philosophy as the highest form of self-consciousness. For Gentile self-consciousness is ultimate reality. Self-consciousness is the one thing we are sure of, and it is a sufficient clue to the interpretation of reality, for all

reality can be adequately conceived as self-consciousness. For Gentile this self-consciousness (or mind or spirit) is a more compact unity than it is for Croce, who attributes to it four different kinds of activity. Gentile rejects the view of such a quadruple cleavage, and insists on the complete unity of self-consciousness. The inevitable distinction between the knowing subject and the known object is no real difficulty, for in self-consciousness we find both, and it is the same mind that is at once subject and object, or knower and known, and each of these is the whole mind, not merely a fragment of it. The object of cognition is therefore always consciousness or mind, which self-consciousness generates in thinking it, so that " nothing is but thinking makes it so " in the very process of self-development. And just as the self-consciousness of a finite mind or spirit is immanent in each of its experiences, so the universal self-consciousness or spirit is immanent in each finite self-consciousness. Finite minds are therefore only moments or aspects of the universal mind which at once is and creates the universe. Although the subjective and objective phases or moments of self-experience (finite or cosmic) are not really separate, yet they are distinguishable. Art, according to Gentile, is mainly concerned with the subjective aspect, whereas religion is mainly concerned with the objective aspect. Philosophy, on the other hand, is concerned with the two together, that is, with self-consciousness or reality in its integrity. Philosophy, according to Gentile, is the complete form in which art and religion are brought together and reconciled, so that it represents the Truth, complete actuality, or the Spirit. Thus the philosopher not merely contemplates reality, but in a measure creates it.

[*L'atto del pensare come atto puro*, 1912 (Eng. Tr. *The Theory of Mind as Pure Act*, London, 1922).]

J. Royce (1855–1916) was the best known American idealist. His philosophy was in some ways like the Absolute Idealism of Bradley. Beginning with the consideration of finite ideas he pointed out that these are not mere images, but imply some mode of action, and therefore some purpose. The purpose constitutes the internal meaning of an idea. Ideas, moreover, possess an external as well as an internal meaning, the external meaning consisting in their reference to objects beyond themselves. But no object can be real independently of the knowledge related to it. And in order to be related the object and the idea must have something in common. From this Royce concludes that the reality of these objects of reference consists in their fulfilment of the inner meanings of the corresponding ideas. The reality of an object is thus conceived as the realisation in experience of the purpose involved in the internal meaning of an idea. Whether this purpose is or is not fulfilled can only be judged by the idea itself, which is thus construed as having a purpose and will of its own. In this way thought came to be conceived by Royce as a conscious life in which ideas embody their purposes in objects. " To be " means, in the last resort, to express " the complete internal meaning of an absolute system of ideas," because reality in its fulness must fulfil all ideas. And so finite ideas must be assumed to be absorbed in one complete system of ideas and one all comprehensive purpose which finds its satisfaction in the total realm of

existence. This Absolute Experience, of course, embraces also much that is beyond finite experience. Royce, however, did not conceive of human individuals as merely engulfed in the Absolute, but as conserved in some way. Each individual expresses in his own way something of the absolute or divine will, and so constitutes a unique part of the unique Whole. Even time, according to Royce, is not merely superseded, in the Absolute, by an eternity that is utterly different from it. He would say rather that eternity is the Absolute's simultaneous apprehension of all time, somewhat in the same way as a melody is the simultaneous apprehension of a certain sequence of notes.

The moral philosophy of Royce is noteworthy for the novel character of its ultimate principle, namely, " loyalty to loyalty." By " loyalty " he meant a person's devotion to a cause greater than himself. When a person, who is loyal to one cause, also respects other people's loyalties to other causes, and co-operates with the spirit of loyalty wherever he finds it, then he practises loyalty not only to his cause but also to loyalty generally. This is " loyalty to loyalty," the gradual extension of which Royce hoped would eventually bring to birth " the Great Community," and bring to an end all international discord.

[*The World and the Individual*, New York, 1900, 1901 ;
The Philosophy of Loyalty, New York, 1908 ;
The Problem of Christianity, New York, 1913 ;
Lectures on Modern Idealism, New York, 1919.]

W. E. Hocking (b. 1873) is still elaborating a philosophy which he describes as " mystical realism," but which admittedly also contains some elements derived from idealism, naturalism, and pragmatism. Perhaps it is idealist first and foremost. This seems to be implied in Hocking's assertion that " idealism is not so much a separate type of philosophy as the essence of all philosophy." One of the most interesting features of Hocking's philosophy is the view that sense experience is a common link between many selves, and that thereby we get to know directly not only other human selves but even God. " I have sometimes sat looking at a comrade, speculating on this mysterious isolation of self from self. Why are we so made that I gaze and see of thee only thy wall and never thee ? This wall of thee is but a moveable part of the wall of my world ; and I also am a wall to thee. We look at one another from behind masks. How would it seem if my mind could but once be within thine, and we could meet and without barrier be with each other ? And then it has fallen on me with a shock—as when one thinking himself alone has felt a presence —that I *am* in thy soul. These things around me are in thy experience. They are thy own ; when I touch them and move them I change *thee*. When I look on them, I see what thou seest, and I experience thy very experience. For *where art thou ?* Not there, behind those eyes, within that head, in darkness fraternising with chemical processes. Of these, in my own case, I know nothing and will know nothing ; for my existence is spent not behind my wall, but in front of it. . . . And there art thou also. This world in which I live is the world of my soul ; and being within that, I am within thee. I can imagine no contact more real and thrilling

than this ; that we should meet and share identity, not through ineffable inner depths (alone), but here through the foregrounds of common experience, and that thou shouldst be—not behind that mask—but *here* pressing with all thy consciousness upon me, *containing* me, and these things of mine. This is reality, and having seen it thus, I can never again be frightened into monadism by reflections which have strayed from this guiding insight." Hocking identifies the primary object of knowledge with sense experience itself, and objectivity with social agreement. Man's recognition of the objectivity of Nature therefore presupposes the simultaneous recognition that at least one other self or mind has a like knowledge of the same content. In the last resort, however, there must be a mind other than human to give objectivity to Nature. For the human self is itself dependent upon Nature, so Nature cannot be dependent on it. The " Other Mind," in the last resort, must therefore be God, the universal Knower, who gives objectivity to all knowledge, even to our knowledge of our fellow men. Hocking, in fact, regards the whole world as a self. " This word self indicates chiefly that the mental life within the world has its unity, and that all the meanings of things cohere in a single will." The ultimate evidence for the selfhood of the whole world is to be found in immediate experience. " We, as a group of human selves, know that we are not alone in the universe : that is our first and persistent intuition." But the self of the universe is infinite in its depth and mystery. And human life is a reaching out to the reality of things as a region in which the discovery of value need never end. The human self spans past and future, lives on values, and is free, determining out of a matrix of many possibilities which one shall become fact. But the human self is not all these things from the beginning—its freedom and its immortality must be won. In these respects man is the creator of his own destiny.

VI. MONADISM OR SPIRITUAL PLURALISM IN ENGLAND AND RUSSIA

The Earl of Balfour ([illegible]) a defender of philosophic scepticism. But his defence of philosophic scepticism was intended to be a defence of religious faith, or at least of a spiritual point of view. His early years had been spent in the atmosphere of the conflict between science and religion which followed Darwinism. Balfour was impressed by the general assumption that the teachings of science were beyond question. It appeared to him that the credentials of science (as expounded in Mill's *Logic*) were no better than those of religion. And his sceptical attack on the foundations of science was planned in defence of the foundations of faith. He contended that the two main " creeds " (religion and science) by which human life is guided should be regarded as resting on separate bases, and that discrepancies between the two must not be regarded as more unfavourable to religion than to science. In his

later work he was not content with this divorce between science and religion, their mere agreement to differ, but tried to bring them into the closest possible harmony. He held that science itself can only be saved from corroding scepticism if we assume the existence of God as the source of all knowledge. Contrasting his own with Descartes' escape from doubt, Balfour said : " Descartes rests the belief in science on a belief in God. I rest the belief in God on a belief in science." He was not really sceptical about science. He admittedly accepted common-sense beliefs and science as true, or at least as on the way to truth. But he insisted that the only way to justify such a conviction was to place it in a theistic setting. His main reasons were as follows. Science is avowedly based on perception, yet concludes in the end that the things perceived are really very different from what they appear to be in perception. All the wealth and variety of the world of perception are reduced by science to systems of imperceptible electrons and protons. Its conclusions seem to contradict its perceptual data. Again, according to the theory of evolution human capacities have been evolved as instruments of survival. They may not be capable at all of dealing with merely theoretical problems, which have no survival value. Yet our common-sense beliefs seem inevitable, and even scientists and sceptics perceive things in the same way as others do, and make the same kind of assumptions about their causal connections, etc. The only ground for believing in the accuracy of these perceptions and assumptions, according to Balfour, is the supposition that all knowledge draws its inspiration from God, who guides human reason to its highest results, which exceed the bare needs of survival, but are necessary to the ascent of man.

Turning next to the realm of morals, Balfour rejected the view that the highest loyalties, the most devoted love, the noblest self-sacrifice, could be regarded as the waste product of the process of adapting human organisms to their environment. Natural Selection, he insisted, " must be treated as the instrument of purpose, not simply as its mimic. . . . Ethics must have its roots in the divine, and in the divine it must find its consummation." Similarly with æsthetic values. " When we look back on those too rare moments when feelings stirred in us by some beautiful object not only seem wholly to absorb us, but to raise us to the vision of things far above the ken of bodily sense or discursive reason . . . we must believe that somewhere and for some Being there shines an unchanging splendour of beauty, of which in Nature and in Art we see, each of us from our own standpoint, only passing gleams and stray reflections."

Thus the three lines of argument converge to show, according to Balfour, that all that is best in human nature, whether associated with knowledge, goodness, or beauty, needs God for its support if it is to preserve its full value. And God is on the side of Truth, Beauty, and Goodness. He guides cosmic evolution, and from Him flows the inspiration which helps the growth of knowledge, æsthetic joy, and love.

[*A Defence of Philosophic Doubt*, London, 1879, 2nd ed., 1920 ;
The Foundation of Belief, London, 1895, 8th ed., 1901 ;
Theism and Humanism, London, 1915 ;
Theism and Thought, London, 1923.]

J. Ward (1843–1925) agreed with earlier and contemporary idealists in maintaining that actual experience does not involve a dualism of matter and mind, but a duality of subject and object, and that this duality-in-unity is consistent with a spiritual monism in which the unity of nature is conceived to be the counterpart of the unity of experience. But, unlike other idealists, Ward declined to make the Absolute his starting-point, preferring to begin with the plurality of reals, and proceeding to find out how far such a more empirical and less speculative start may lead him. He begins, accordingly, by assuming the existence of an indefinite variety of psychical beings of all grades, some much higher than human minds, others much lower, but all tending to self-conservation and self-realisation. This conception of all entities as psychical, indeed conative, individuals Ward based on the principle of continuity—the absence of leaps in nature. Now such mental, striving entities, or monads, must be endowed with spontaneity. They cannot be regarded as subject from the the first to merely mechanical laws. The prevalence of natural laws and the appearance of mechanism in nature are best explained as the transformation of spontaneous activity into regular habits, which may easily appear to be even more regular or uniform than they really are, if we apply to them statistical methods. Moreover, the co-operation and organisation of monads leads to progress by a kind of creative synthesis, just as a melody comes into being when single notes follow in a certain sequence, or a certain level of culture is attained when society is organised on certain harmonious lines. As the final goal of such progress one may think of "the eventual consummation of a perfect commonwealth, wherein all co-operate and none conflict, wherein the many have become one, one realm of ends." In this way Ward believed that without any extravagant speculation he had succeeded in construing the world as a plurality of psychical beings, or monads, primarily independent as regards their existence, and yet always mutually acting and reacting upon each other, "an ontological plurality that is yet somehow a cosmological unity." He felt, however, that all this seemed to suggest "some ground beyond itself." And he fell back upon theism to supplement his spiritual pluralism. While rejecting the ordinary ideas about creation he held that God in some sense sustains the world by a continuous act of self-limitation. Ward realised, however, that the theistic part of his philosophy was more speculative than the rest. Like Kant he treated it as a matter of faith, and based the belief in God and in immortality on moral grounds.

[*Naturalism and Agnosticism*, London, 1899, 4th ed., 1915;
The Realm of Ends, Cambridge, 1911, 3rd ed., 1920;
Psychological Principles, Cambridge, 1918, 2nd ed., 1920;
A Study of Kant, Cambridge, 1922.]

W. R. Sorley (b. 1855) has devoted himself mainly to the ethical aspects of philosophy. Value experiences, he insists, are as much data of experience as are sense-perceptions, and must be taken into account in any philosophical view of reality as a whole. The experience of value is subjective, as is all experience. But experience also refers always to an object other than the experience itself. This applies to value-experience

as well as to cognition. The fact that value-experience implies feeling and desire makes no radical difference. It may have reference to feelings or desires of persons who are as objective to the subject of the value-experience as physical things are to the subject of sense-experience. Values are objective although, or just because, they are characteristics of the personal life. For persons belong to the order of reality. And they are the bearers of value, for values are manifested in their characters and lives. The goodness of the good man is as objective as the man himself. If it is objected that human life is more often a mere striving after values rather than a realisation of them, even so, it may be pointed out, the moral principles which induce people to pursue ideals, even unattainable ideals, are as objective as are natural laws, though they differ in the objective orders to which they apply and in their modes of application. Natural laws apply to phenomena in space and time, and their validity consists in their reality. Values apply to personal life, and their validity consists in expressing an ideal which people feel they ought to realise. Natural laws constitute the causal order of the existing world; values constitute its moral order. And a theory of reality must recognise and harmonise both orders. Sorley's solution of the problem is briefly as follows. The universe consists of a Supreme Mind, or God, to whom finite minds and their environment owe their reality. God is the creator, the essence and source of all values, but is willing that these values should be shared by the free minds who owe their being to Him.

[*The Ethics of Naturalism*, London, 1885, 2nd ed., 1904;
Moral Values and the Idea of God, Cambridge, 1918, 2nd ed., 1921.]

A. E. Taylor (b. 1869) is essentially a moral and religious philosopher. He maintains that philosophy " has to be content to recognise that in the sciences, in history, in morality and religion, it is dealing with a reality which is in the end simply ' given,' and not to be explained away." In fact he is more than suspicious of any system of philosophy that leaves no unexplained mystery at the root of things. His own philosophy mainly seeks to harmonise the exigencies of scientific thought with the moral and religious demands of life. Morality postulates freedom on the part of the agent and real contingency in nature. This, however, is not in conflict with science. For science itself recognises a principle of indetermination. The natural order is not necessarily the only one. Taylor insists that there is no reason to suppose that religious experience is concerned with anything less real than is any other part of human experience, and that the reality of religious experience is evidence of the reality of its object. "It is only because the absolutely Good and utterly Adorable has not left Himself without a witness in our hearts that we feel the need of an object of worship and are driven from the worship of trees or streams, or animals or mighty men or anthropomorphic deities, towards an object in which our adoration can at last find rest because that on which it is directed is adequate to sustain it." Taylor's view, accordingly, is frankly theistic. The ultimate ground of things, he holds, is a single supreme reality which is the source of everything other than itself, and has the characteristic of being intrinsically complete or perfect, and

an adequate object of adoration or worship. This supreme reality is best conceived after the analogy of the human spirit at its very best. Thy reality of moral progress, according to Taylor, postulates also the reality of time, of causal agency, of free-will, and of permanent personality. The moral life is a life of tension between the temporal and the eternal, and is only possible to a being which is neither abiding nor simply mutable, but both at once. It is a life of real adventure which begins with " nature " and ends in " supernature." The attainment of a fully unified personality depends on our finding our principal good in God, the concrete unity of all good in its source. The implication of morality is thus a double one. It points to the existence of God as the absolute and final plenitude of good, and to an eternal destiny for the moral person whose aim is the fruition of the good. Taylor's religious philosophy culminates in the theology from which, no doubt, he started. Its three main dogmas concerning God are these. (1) God is the Creator, Redeemer, and Sanctifier. (2) He is the lover of men. (3) The life of God is essentially an activity of self-communication (which is the meaning of the orthodox doctrine of the Trinity). Taylor also ventures to forecast the nature of man's life " in Heaven " after his present life of " probation." The process of character-forming will be over, but the activity issuing from character will remain.

N. O. Lossky (b. 1870), the Russian philosopher, advocates an intuitionist epistemology and a spiritualist ontology. All knowledge is based on immediate intuition. Objects are apprehended directly, without the intervention of mediating representations, but they are trans-subjective, that is, transcendent in relation to the consciousness which apprehends them in intuition. Intuition, however, is not yet knowledge. For although objects enter consciousness in all their fullness and with all their relations to one another and to the rest of the world, yet the subject must exercise his powers of discrimination and integration in order to construe all these things correctly. Then only is there knowledge. But the mind does not create or construct these objects or their interrelations ; it only construes them. Knowledge only reflects, so to say, the objective facts and their systematic interrelations in the cosmos. This relationship between the subject and the intuited objects is not the outcome of any causal operation of the objects on the subject but is due to an " epistemological co-ordination," perhaps a kind of pre-established harmony or mutual adaptation, between conscious subjects and the objects of which they become conscious. Lossky favours the conception of matter (or atoms) as events or processes of attraction and repulsion. But he regards these processes as manifestations of forces exercised by substances which are all spiritual though only some of them are fully conscious. Physical processes are, therefore, never entirely mechanistic, but always psycho-physical, and consequently purposive, though not always consciously so. Lossky follows Aristotle and Driesch in assuming the operations of an " entelechy " to account for the peculiarities of organic life and behaviour. But he

conceives the principle of life not as a force but as a substance exercising the creative activity of a being that is the source of its laws and not their slave. The universe is conceived by Lossky after this analogy. The world, he says, is an organic whole. By an organic whole he means a whole which is prior to its parts, so that the parts can only come into being and continue to exist within the whole. And " the unity of the intelligible world is not a functional unity of abstract ideas but a community of beings that live an infinite life." But such an organic whole cannot be self-existent. It must be grounded on some higher principle. So the unity of the cosmos compels Lossky to recognise " a super-cosmic principle, the Absolute, as the source of a plurality of substances which form a unity more intimate than the abstract unity of the world, and nevertheless remain free in their activity." In this way Lossky finds a philosophical basis for theism, or for Christian theology, in his " Organic Concrete Ideal-Realism," as he calls his philosophy, which seems to oscillate between spiritual pluralism and absolute idealism.

VII. NEO-TRANSCENDENTALISM (NEO-KANTIANISM AND PHENOMENOLOGY) IN GERMANY

O. Liebmann (1840–1912) was mainly responsible for the German philosophic movement which took for its motto the refrain " Back to Kant," and is consequently known as Neo-Kantian philosophy. He tried to show that the philosophical systems of Fichte, Schelling, Hegel, Herbart, Schopenhauer, etc., although they all claimed to be the successors of Kant, really misrepresented his views. For they all made the " thing-in-itself " (or Absolute, etc.) the central idea of their philosophies, whereas it played no such rôle in the philosophy of Kant, who regarded all knowledge as restricted to the realm of relationships, and as incapable of reaching the thing-in-itself (or Absolute). Liebmann applied the same kind of criticism to the empiricist or positivist tendencies in philosophy. The *data* of experience, which positivism treats as ultimate facts, are not purely objective entities, for they have already been affected by the general forms of thought. Pure " matter " of sensation, any kind of entity or reality untouched by the forms of cognition, is just as inaccessible to us as is the thing-in-itself. Nor is there such a thing as " pure experience," in Mill's sense, for all experience or empirical cognition is already determined by certain logical principles by means of which we try to understand natural phenomena. Liebmann enumerated four such principles, namely, those of real identity, of continuity of existence, of conformity to law, and of the continuity of events—these four principles between them constituting the " logic of matters of fact," which must be used in all scientific investigations, though not dogmatically but only regulatively.

[*Kant und die Epigonen*, 1865;
Zur Analysis der Wirklichkeit, 1879.]

H. Cohen (1842–1918) was the chief of the Neo-Kantian philosophers. He was the first to give a full and critical interpretation of the philosophy of Kant, treating the transcendental method as its central feature. Cohen insisted that a philosophical theory of knowledge must set out from the exact or mathematical sciences. Kant himself actually had Newtonian science always in mind, and, when attempting to put philosophy on the safe path of science, he measured the scientific character of an investigation by the amount of mathematics which it contained. Cohen maintained that philosophy should ascertain the possibility, and the conditions of the possibility, of all the ideas and principles which the exact or mathematical sciences of nature treat as their stock realities. Accordingly he paid special attention to the fundamental concepts of mathematics and mathematical physics, studying more particularly the history of the method of infinitesimals. He endeavoured to show that the ideal of the infinitely small, as used by Newton and Leibniz, is really the fundamental intellectual instrument of the scientific study of reality. Cohen insists that reality is never merely " given," whether in sense-perception or in intuition. It is always produced, in various ways, by means of thought. And it is the function of logic to trace these various ways in which thought produces the objects. Kant's great merit, according to Cohen, was that he initiated such a " logic of origin," in place of the previous logic of ready-made objects and forms. And Cohen set himself the task of developing this kind of " logic of origin," so as to show how thought produces the real objects of mathematics and mathematical physics. In a way, then, it may be said that Cohen attempted to drop the teaching of Kant's transcendental *æsthetics* and to begin at once with the transcendental *logic* dispensing with the assumption of given sense material, and so identifying reality with thought. His system is, accordingly, described as " logical idealism."

[*Kants Theorie der Erfahrung*, 1871 ;
Kants Begründung der Ethik, 1877 ;
Kants Begründung der Aesthetik, 1899 ;
Logik der reinen Erkenntnis, 1902 ;
Ethik des reinen Willens, 1904 ;
Aesthetik des reinen Gefühls, 1912.]

W. Windelband (1848–1915) attempted to save philosophy from the one-sided tendency to pay undue attention to the natural sciences to the neglect of the historical studies, which are concerned with the various phases of human culture. This tendency had been encouraged to some extent by Kant, who had based his theory of knowledge on mathematics and mathematical physics. In his day these were the most scientific studies. History was classed with *belles lettres*, and left to the care of literary artists. But things have changed since then. History also is now studied in an objective or scientific spirit. It also is an empirical study: And its very difference from science may make it more helpful in the study of the problems of philosophy. Science is " nomothetic," that is to say, it is mainly concerned with the discovery of laws or regularities, and for this reason is general and abstract, is concerned with classes or types,

not with individuals as such, but only as specimens of the types. History, on the other hand, is "idiographic," that is to say, it is concerned with individuals and individual events in all their particularity. And for the understanding of our ultimate problems a knowledge of the individual and temporal (History) is more important than is the knowledge of the general and timeless (Science). It is sometimes urged that the historian needs the aid of psychology, and psychology is a natural science. But the psychology that is of value to the historian is not the scientific psychology of abstract generalities, but that concrete, intuitive understanding of men, and insight into character, which is an art rather than a science, and cannot be learned or taught. In relation to human interests and appreciations of value, the unique or the individual is far more significant than what is typical or general, for feeling is blunted by repetition. History, moreover, is concerned not only with the temporal and mutable, but also with the eternal. For although history is primarily concerned with the successive stages in the development of human culture, yet the cultural values with which it deals constitute between them a kingdom of eternal values, for their claims to universal validity imply the existence of a "consciousness in general." The eternal values (logical, ethical, and æsthetic) realise themselves in history, namely, when men become conscious of them as "norms," or guiding principles, of conduct. To follow these norms, or ideals, involves no breach with the natural laws of the mind. For these norms themselves, as soon as we realise their validity and value, exercise a psychical force upon us. The same is true of our sense of responsibility. In this way education, including self-education, is possible not in spite of natural laws, but through their mediation. Turning next to the questions of immortality and God, Windelband challenges the morality of Kant's moral argument. Is it moral, he asks, to feel the need of a reward for virtue? Man may, of course, do his utmost towards the realisation of the good, and so gain a kind of immortality through his participation in the eternal values; but that is not what people commonly understand by immortality. This kind of individual immortality, however, is not rendered probable by the modern tendency to regard the soul as a function rather than as a substance. And the general acceptance of the theory of psycho-physical parallelism leaves no ground for the view that the soul can outlive the body. Windelband also finds it very difficult to reconcile the existence of God with the existence of evil. The world of reality and the world of eternal values appear to him as an irreconcilable duality. They are not entirely divorced, for the one always points to the other. Yet the world of reality seems to contain much that is either hostile or indifferent to values. And this duality is unfavourable to a belief in the existence of God, though one might identify the Godhead with the World of Eternal Values. Windelband, however, admits that this dualism is an incitement to human endeavour. If the real were valuable, and the valuable real, man would have nothing to strive after.

[*Präludien*, 1884, etc.;
Geschichte und Naturwissenschaft, 1894, etc.;
Einleitung in die Philosophie, 1914 (Eng. Tr. *Introduction to Philosophy*, London, 1921).]

R. Eucken (1846–1926) was an impressive apostle of the life of the spirit, in support of which he elaborated a more or less theistic or Christian metaphysic, though he rejected some of the most characteristic dogmas of Christianity. The highest reality, according to Eucken, is a Spiritual Life, or Living Spirit, which is above Nature and yet pervades it in such a way that Nature can be a stepping-stone to it. This supernatural Spiritual Life is not something finished once for all but a living movement towards ever greater and deeper spirituality. By some kind of mystical intuition man may get to know this Spiritual Life. He can also participate in its progress. All inspiration in science, art, religion, etc., is at once the outcome and evidence of such human participation in the Life of the Spirit. For Truth, for instance, is not the creation of man. It exists in the Realm of the Spiritual, where man only discovers it. Only such a spiritual source of Truth can account for our faith in the power of Truth and our devotion to the pursuit thereof. Truth, indeed, is the measure of man, not man the measure of Truth. In the Life of the Spirit Truth has a reality and a value independently of man. Other evidence of the reality of the Realm of the Spiritual may be found in the fact that in times of tribulation most people seek refuge in this Spiritual Realm or Kingdom of Heaven. But real participation in it requires more than mere contemplation; it requires active moral endeavour, for the Spirit is essentially moral and the embodiment of all values. Nature, indeed, is not to be underrated. For it embodies much intelligence, as is evident from the laws and interconnections of natural phenomena, and from the natural evolution of increasingly higher orders of natural beings. Indeed, the human mind itself is a product of Nature. Nevertheless, Nature stops short of Spirit, and is at best only a preliminary stage on the way to the Spiritual Life. For the Spiritual Life is not the product of Nature, but its ultimate foundation and goal. Hence although Eucken has every respect for science and its achievements, he maintains that it is history, the life-stories of great personalities, rather than science that brings us into closest contact with the Realm of the Spirit. He also insists that the intellectual methods of science, the methods of discursive reason, though they are suitable for the acquisition of knowledge of natural phenomena, are not adequate to the knowledge of the Spiritual Realm. For this purpose another method is required, namely, the " noological " method, as Eucken called it. By this he meant some kind of mystical, intuitive penetration on the part of our whole personality (as distinguished from our mere intellect) into the Life of the Spirit, which thereby takes possession of our consciousness. Eucken sometimes spoke of this Spirit or Spiritual Life in pantheistic terms, but for the most part he identified it with a personal God, in the sense of theism. On such a philosophic and religious platform Eucken took his stand and endeavoured to rouse his generation, to make them see the superficiality of the materialistic culture of the age, and to persuade them to strive after a deeper and more spiritual life. Human existence, he urged, is empty, and devoid of all significance, unless religion raises it to the other-worldly heights of the Life of the Spirit.

[*Die Einheit des Geisteslebens*, 1888;
Die Lebensanschauungen der grossen Denker, 1890 (Eng. Tr. *The Problem of Human Life*, London, 1909);

Der Wahrheitsgehalt der Religion, 1901 (Eng. Tr. *The Truth of Religion*, London, 1901);
Grundlinien einer neuen Lebensanschauung, 1907 (Eng. Tr. *Life's Basis and Life's Ideal*, London, 1912).]

E. Husserl (b. 1859) is the leader of the philosopical movement known by the name of Phenomenology (not to be confused with Phenomenalism). Phenomenology is primarily an epistemological method, which may be traced back to various other philosophers of the nineteenth century, and more especially to F. Brentano (1838–1917) and A. Meinong (b. 1853). Brentano, in his *Empirical Psychology* (1874), drew attention to the "referential" (or, in Scholastic terminology, the "intentional") character of mental processes. They all refer to an object, real or imaginary. Whether we perceive, or imagine, or judge, or desire, or love, or hate—there is always "something" that we perceive, or imagine, or judge, etc. This fact served as the basis of Meinong's study of "objects as such." (*Gegenstandstheorie*), with a view to determining the *a priori* characters of various objects independently of the psychical experiences whose objects they are, and independently even of their own existence. The Phenomenology of Husserl is largely a development of this kind of epistemological method, though he eventually associated with it also an idealistic ontology. To begin with, Husserl emphasises the fact that consciousness or experience, or cognition in particular, has two poles—a subject-pole and an object-pole (or a *noetic* and a *noematic* aspect). In other words, there is always a subjective activity, a correlated object on which it is directed, and some kind of nexus between them. There are many different kinds of activities in consciousness (perception, thought, appreciation, etc.) and many kinds of correlated objects (existents, universals, values, etc.). And the application of the phenomenological method consists in living through each of these activities in turn, and introspectively observing the whole structure of the activity and its object and the nexus between them (the subject and object "bracketed together," so to say). This procedure is different from the ordinary consciousness with its almost complete absorption in the object; and it is different from the usual psychological introspection with its concentration on the subjective. The phenomenological method started as a purely descriptive method proceeding by way of thoroughgoing analysis, and without making any presuppositions. It was intended, in fact, to carry out the main task of the Critical Philosophy in much more thorough fashion than Kant had done. Husserl meant his method to be transcendental and radical. At the first blush the tendency of his method appears to be realistic. Husserl, for instance, maintains that physical objects (unlike mental experiences as such, or also universals) can only be apprehended in part or in perspective, so that apparently they are always objectively more than what they are in empirical consciousness. But the tendency soon appeared to be definitely idealistic; and it looks as though his idealistic ontology had influenced Husserl's phenomenological method from the very beginning. The points of more general interest may be briefly indicated as follows. The mind's objects and the activities by which it apprehends them are not ultimately different in kind, only in degree. The acts of the mind may themselves become its objects, and the mind is

just as active when it has itself and its activities for its objects. What the mind gets to know of its objects is only their "whatness," not their "thatness," that is their universal characters, their "essences," not their peculiarities as particular existents. The phenomenological method is a method of "intuiting essences" (*Wesensschau*). In the last resort, moreover, the "essences" which the mind comes to know are really the forms of its own *a priori* activity. Husserl seems to assume that all "being" is "being in consciousness." The objectivity of objects is due to the fact that over and above the empirical ego there is a transcendental ego, in relation to which the empirical ego is only one object among many. And it is the transcendental ego that constructs all objects and their essences according to its own *a priori* forms. Lastly, all the transcendental egos jointly constitute one supreme transcendental Being or Spirit, rather like the Absolute of Hegel.

VIII. BIOTISM, VITALISM, PRAGMATISM, INSTRUMENTALISM, AND FICTIONISM IN FRANCE, GERMANY, AND THE UNITED STATES

H. Bergson (b. 1859) marks the climax of the reaction of French Philosophy against scientific mechanism. His philosophy is mainly directed to the vindication of the spiritual character of the universe as a whole, without denying altogether the reality of matter and of natural law. The key concepts of his system are those of change, activity, freedom, creative evolution, duration, and intuition; and his philosophy is commonly described, accordingly, as the "philosophy of change" or of "creative evolution."

Ultimate reality, according to Bergson, is neither material nor mental, but something less determinate from which both mind and matter derive. It is "change," a flow of events, a surging of *life*, moving incessantly to new forms. It is not static, though he also calls it "duration" or real time. But this must not be conceived abstractly as a mere sequence of instants. "Duration [says Bergson] is the continuous progress of the past which gnaws into the future and which swells as it advances." This is best seen in the case of human life. Our whole past follows us at every instant. "All that we have felt, thought, and willed from our earliest infancy is there, leaning over our present, which is about to join it. . . . What are we, in fact, what is our *character*, if not the condensation of the history that we have lived from our birth—nay, even before our birth, since we bring with us parental dispositions? Doubtless we think with only a small part of our past, but it is with our entire past . . . that we desire, will, and act." Such is duration or real time. In it the whole past

is telescoped in the present. Moreover, it involves not only real and incessant change, but a certain freshness or novelty in every new change, since each successive change in a sequence has a richer past permeating it. The sequence of changes is, therefore, a creative evolution. Spirituality is just this kind of memory, this kind of concentrated activity in which the past interpenetrates the present. But sometimes there is a relaxation of this activity, and the result is matter. Broadly speaking it may be said that consciousness is interpenetration without externality, whereas matter is externality without interpenetration.

Now the evolution of life has followed three different and independent directions—the vegetative, the instinctive, and the intelligent (or rational). Instinct is the faculty of using organic instruments; it is a kind of unconscious practical skill. Intelligence is the faculty of making and using inorganic instruments, and develops into conscious thought about relations between things. Intelligence (owing to its original function of making inorganic tools) tends to regard all reality as though it were inert matter. Hence the scientific tendency towards mechanistic explanations. This tendency must be corrected by means of intuition, which is instinct become self-conscious and capable of reflecting upon its objects. But intuition and intelligence must co-operate if we are to avoid mechanism, at one extreme, and mysticism, at the other.

For Bergson, consciousness or spirituality is exemplified by memory, not by perception. Perception is only incipient or nascent action, not consciousness at all. The contrary view is based on the frequent mingling of memory with perception. This only shows that spirit can rest on matter, yet they remain distinct. Similarly, however intimately consciousness may be connected with the body, or with the brain, they are nevertheless distinct. Consciousness is not a mere function or epiphenomenon of the brain, but rather uses the brain as an instrument. " There is a close connection between a coat and the nail on which it hangs, for if the nail is pulled out the coat falls to the ground. Shall we say, then, that the shape of the nail determines the shape of the coat, or in any way corresponds to it?" No more is one entitled to say that psychical facts are determined by the cerebral facts with which they are associated. And mind is essentially free or creative, not mechanical, in its activity. Even if it is admitted that our past influences our present, our freedom is not affected thereby. For freedom is essentially self-expression, self-determination, and our conduct is free just when it expresses what we are.

The functions which Bergson attributes to matter are not entirely evil. It is the principle of individuation, it divides the sea of life into separate individualities who can each develop distinctive personalities. Moreover, the very obstacles which matter presents serve as an incentive to the intensification of activity, which is life. " By the resistance matter offers, and by the docility with which we endow it, it is at one and the same time obstacle, instrument, and stimulus." Life, however, always retains a certain corporate, social, or integral character, which prevents its dissipation in sheer, incoherent individualism. Life finds full satisfaction only in society. The best and most live man is " the man whose action, itself intense, is also capable of intensifying the action of other men, and, itself generous, can kindle fires on the hearths of generosity." In the last

resort, moreover, " all the living hold together." The central radiation of life is God. And God is " unceasing life, action, freedom."

[*Essai sur les Données immédiates de la Conscience*, 1889 (English Tr. *Time and Free Will*, London, 1910);
Matière et Mémoire, 1896 (Eng. Tr. London, 1911);
L'Evolution créatrice, 1907 (Eng. Tr. London, 1911);
L'Energie spirituelle, 1920 (Eng. Tr. *Mind-Energy*, London, 1920).]

H. Driesch (b. 1867) is the leader of contemporary Vitalism or Neo-Vitalism, the chief tenet of which is that the phenomena of life cannot be adequately explained in terms of physico-chemical processes. Driesch advocates a " dynamic teleology " in opposition to the mechanistic theory of life, according to which all vital phenomena are determined solely by physico-chemical factors. Driesch adduces the following evidence against biological mechanism. (*a*) A complete organism can be developed from an incomplete egg. Any one cell of a two-, four-, or eight-celled blastula (segmented ovum) can produce a complete embryo; and one cell of the four-celled blastula produces a different organ according as one or more of the remaining cells have been removed. Hence some special vital factor must be operative, over and above the physico-chemical factors. (*b*) Similarly, in the case of the blastula of the echinoderm (the sea-urchin, etc.) which is normally formed by the division of the egg, any one cell, or group of cells, can function instead of the whole egg. This is beyond mere mechanism. (*c*) If part of the brain of a living animal is removed, then after some time its functions are carried out by another part of the brain. (*d*) In the case of human behaviour experiences are accumulated and stored in the form of ideas. Now there are certain mechanisms which in a sense accumulate experiences. A phonograph, for instance, does so. But this kind of mechanistic storing is totally different from that through ideas, which can, moreover, be used for the construction of other, new ideas.

Vital reactions, then, according to Driesch, are not to be explained mechanistically. They are more like intelligent replies to a question, or the mutually responsive parts of a conversation. What determines the vital reaction is the complete animal or some vital unit which functions for the whole animal. In this connection Driesch re-introduces the Aristotelian idea of an *entelechy*. An entelechy is, so to say, a plan pervading a living organism, and its power is revealed in the development of the organism, and in all its biological reactions. If, for instance, a triton loses a foot, the entelechy responds by forming a new one very like the lost one. And so in all cases where special re-adjustments are called for, as in the examples mentioned above.

Driesch has applied the idea of entelechy also to the study of psychology. He treats psychology in a kind of behaviouristic manner as concerned with the study of organisms in action. Animal behaviour (including human behaviour) is very like animal development. Both are directed to a certain purpose or end. And just as the development of an animal is directed by an entelechy, so its behaviour is directed by an analogous *psychoid*, or an inborn intelligent urge to action. This urge finds expression

in the first movements of new-born animals. It is prior to all experience. In course of time the animal accumulates experiences and acquires knowledge by which its activities are then regulated. In this way " secondary purposes " and " secondary knowledge " come into being, as distinguished from the " primary purpose " and " primary knowledge " of the original " psychoid."

Driesch, though primarily a biologist, has developed a full-fledged philosophical system somewhat on the lines of German Idealism. Perhaps the most interesting feature of his system is the way in which it is dominated by his idea of entelechy. He inclines to conceive God, or the Absolute, as the ultimate Entelechy of the Universe, and as the ultimate Potentiality of all that comes into being. The conception of such a divine entelechy, considering the teleological character of entelechies, naturally inclines Driesch to believe (though he admits that he cannot prove) that the world has some ultimate purpose.

[*Analytische Theorie der organischen Entwicklung*, 1894;
Science and Philosophy of the Organism, London, 1908;
History and Theory of Vitalism, London, 1914 (German original 1905);
Problems of Individuality, London, 1914.]

W. James (1842–1910) was the leader of the American philosophic movement known as Pragmatism. This term was first introduced in 1878 by C. S. Peirce (1839–1914), and the main idea has been traced to the ancient Sophist Protagoras, who taught that " man is the measure of all things." The philosophy of James is perhaps best understood as a reaction against the excessive intellectualism, and the monism or singularism of absolute idealism and its conception of an eternally finished static world or " block universe." He had a keen feeling for what lives and moves. And to this feeling may perhaps be traced the most distinctive factors in his philosophy—its pluralism, individuality, freedom, novelty. To some extent he was influenced by Renouvier, the French defender of free-will against scientific determinism. Hence there is a certain affinity between James and Bergson. Already in his psychology James laid stress on the *activity* of consciousness or experience, which, under the influence of emotional and practical interests, selects for attention only certain things from a " theatre of simultaneous possibilities," and in this sense " carves out " a world of its own in " the jointless continuity of space and moving clouds of swarming atoms." Turning to human knowledge, James distinguished between *knowledge by acquaintance* (in which objects are apprehended immediately) and *knowledge about* (in which objects are known indirectly by means of ideas). James's pragmatism shows itself in his interpretation of ideas by reference to the practical effects involved, the sensations to be expected, the reactions which have to be prepared. " Thinking is first and last and always for the sake of doing," and " the conception with which we handle a bit of sensible experience is really nothing but a teleological instrument." This implies that ideas must be tested either by the realisation of the sensory expectations or by the success of the prepared reactions. " The ' true ' . . . is only the expedient in the way of thinking, just as the right is only the expedient in the way of

our behaving. Expedient in almost any fashion; and expedient in the long run, and on the whole, of course." If an idea cannot be tested by the fulfilment of sensory expectations we may legitimately "will to believe" it if emotional and practical interests favour it. The idea of God, for instance, is a case in point.

James's world-view, like his pragmatic method, was also largely the outcome of his psychology. He found in "experience" all that was necessary for the construction of reality. As against the idealist assumption that "relations" are the special creations of consciousness, and that a transcendent Spirit has to be assumed to sustain the unity of the cosmos, James contended that "conjunctive relations are just as much matters of direct experience" as are things. In fact, consciousness itself is only one kind of conjunctive relation among experiences. The system of external realities, and the stream of our internal thinking, are really the same "experience" taken in different relations. Such was James's "radical empiricism." His psychology also disposed James to accept the reality of a superhuman consciousness composed of all finite minds. This view seemed to him justified by the evidence of psychical research (automatic writing, mediumship, etc.), the phenomena of multiple personality, and above all by the "varieties of religious experience." These persuaded him of the existence of reservoirs of consciousness, "a more of the same quality" as human minds, a plurality of saving powers, with which man sometimes comes into contact. James approved of theism, but regarded God as finite, or of limited power and responsibility. The world, according to James, is undetermined, so that it is quite possible to realise in it whatever we reasonably think ought to be realised. The good man is a "faithful fighter" in the cause of righteousness, and is justified in his faith in the ultimate triumph of goodness.

[*Principles of Psychology*, London and New York, 1890;
The Will to Believe, London and New York, 1897;
Varieties of Religious Experience, London and New York, 1902;
Pragmatism, London and New York, 1907;
A Pluralistic Universe, London and New York, 1909;
The Meaning of Truth, London and New York, 1909;
Some Problems of Philosophy, London and New York, 1911.]

J. Dewey (b. 1859) teaches a form of pragmatist philosophy known as "instrumentalism." Thought, he maintains, is essentially an instrument of life. So long as life proceeds smoothly people do not think. It is only when the impulse to action is thwarted in some way that people pause to think. Their thought is an attempt to plan their action so as best to meet the difficulties of the situation. And the validity of their thought is gauged by its success—"that which guides us truly is true." The sciences may appear to be interested in knowledge for its own sake. The highly abstract knowledge which they accumulate may appear to be remote from the practical needs of life. In reality, however, the whole quest for truth is an elaborate and potent method of forging effective instruments for the future needs of our practical life. The object of thought is, accordingly, conceived as an ideal, that is, a plan of action. The object is, consequently, not

regarded as something ready-made, but as something which is progressively constructed by the activity of thought. In such a philosophy the moral problem is naturally supreme. Indeed, the initial motive of Dewey's "instrumentalism" appears to have been his desire to overcome the traditional dualism in logical standpoint and method between "science" on the one hand and "morals" on the other. "I have long felt [says Dewey] that the construction of a logic, that is a method of effective inquiry, which would apply without abrupt breach of continuity to the fields designated by both of these words, is at once our needed theoretical solvent and the supply of our greatest practical want." And what chiefly prompted his desire to produce such a joint, practical logic was his enthusiasm for social progress towards liberalism in the highest and widest sense of the term. Instrumentalism is conceived by him as affording a suitable philosophic basis for such liberalism, in so far at least as it is opposed to all that is static and obstructive, and encourages experiment and enterprise in social reconstruction. But, like Windelband, he also maintains that "the next synthetic movement in philosophy will emerge when the significance of the social sciences and arts has become an object of reflective attention in the same way that the mathematical and physical sciences have been made the objects of thought in the past, and when their full import is grasped." One of the chief obstacles in the way of advancing beyond the legacy of that "provincial episode" known as Western European history, is the solicitude of many people about the present and future of religion. But, thinks Dewey, such people "are moved more by partisan interest in a particular religion than by interest in religious experience" as such.

H. Vaihinger (b. 1852) has formulated an idealistic positivism commonly known as "the philosophy of 'as if,'" or "fictionism." It combines Kantian positivism (which confines human knowledge to the empirical) and pragmatism (primacy of the practical reason) with Schopenhauer's voluntarism and pessimism, Darwin's evolutionism, and Mill's empiricism (which reduced reality to sensations and permanent possibilities of sensation). He holds that psychological analysis ends in sensations, feelings, and conations, that epistemological analysis ends in sense-data (or contents of sensation), while physical analysis ends in mass and motion. So far as practical life is concerned all these different ultimate realities harmonise quite well, but thought cannot co-ordinate them in one rational system. This is due to the fact that thought was originally only an aid in the struggle for existence, and is still incapable of dealing with purely theoretical problems. What has happened in the case

of thought is only one instance of a common natural tendency. Namely, what was originally only a means to a certain end may develop far beyond its needs, and emancipate itself from its end to such an extent as to become an end in itself. In this way thought has come to be regarded as an end in itself, and has set itself tasks which are quite beyond it, such as the solution of the problem of the origin and significance of the universe, and similar metaphysical problems. But the solution of such problems is beyond thought—not merely beyond human thought, but beyond any thought as such. Many ideas are, in fact, just deliberate fictions affording merely apparent solutions of theoretical problems. In addition to their empirically verifiable hypotheses, the sciences contain many such deliberate fictions. So do ethics, æsthetics, and religion. What we call reality consists of the contents of our sensations, or sense-data, which force themselves upon us so that we cannot deny them. They exhibit many laws or regularities of coexistence and of sequence; and it is the business of the sciences to ascertain these laws. By means of those sense-data which we call our bodies we can exercise considerable influence upon the rest of the world (consisting of other sense-data). This world contains many manifestations of purpose, but also much that is purposeless. We must take the world as we find it. Myths may be helpful, morally or æsthetically. Many people find satisfaction in the fiction that the world has been created, or is governed, by a supreme and perfect Spirit. But this requires the complementary fiction of an evil opposing power. As to the significance of the world, man must by his practical endeavours try to *put* significance and value into it; he must not expect to *find* value and significance there ready made. Practical life and intuition are higher than speculative thought. In our practical contact with reality all speculative riddles disappear, and our practical work in and for the world is far more important than our theoretical speculations about it.

IX. REALISM, EMERGENT EVOLUTION, AND FLUXIONISM IN ENGLAND, SOUTH AFRICA, AND THE UNITED STATES

S. Alexander (b. 1859) has constructed a philosophic system which has the great merit of unusual harmony with the broad results of modern science and with the whole spirit of science. The stuff of the world, according to Alexander, is Space-Time. Space alone is a mere abstraction, so is Time alone. The concrete reality is the four-dimensional Space-Time. This is the same as pure Motion, for Time is not static. But pure motion is not yet matter in motion, for matter has to be generated first. Within the whole of Space-Time, or pure Motion, point-instants may be distinguished. These are the elementary events. Space-Time has certain categorial characteristics which are consequently pervasive characters of all existents. The categorial characters are existence, universality, relation, order, substance, quantity, number, motion. But besides these universal characters there are also various empirical qualities which

distinguish different classes of objects emerging under special conditions. For Space-Time differentiates spontaneously into many different configurations or collocations of point-instants. The simplest of these consist of motions of various velocities and extents. But when these, or some of them, form certain patterns, then a new quality, namely materiality, emerges. Under certain further conditions such qualities as colour, scent, etc., emerge. Given certain additional conditions, and life emerges. And when such living complexes realise certain further conditions, then consciousness emerges as an additional quality of living bodies. Hence a hierarchy of existents, in which whatever has the higher qualities also has the lower ones from which they emerged. But the relation of a thing to its highest quality is different from its relation to the lower ones. It " enjoys " (or has a direct living apprehension of) its highest quality, but only " contemplates " (or has a merely external apprehension of) the lower qualities. Thus man, for instance, when he perceives a body (maybe his own body), "enjoys" the process of perceiving, and "contemplates" the body. Every conscious process is also a neural process. What is, in this case, " enjoyed " as a conscious process is also " contemplated " as a neural process. A mind is the substantial continuum of processes which have the quality of consciousness. Its cognition of objects is a special case of the more general relationship of " compresence " or togetherness of things, and does not change in any way the qualities of the objects cognised. Now although consciousness is the highest quality of human beings, it is reasonable to suppose that there are still higher qualities in the universe. The highest quality is called by Alexander " deity " or divinity ; and " deity " is conceived to be the highest quality of God in the same way as consciousness is the highest quality of man. The whole universe is the body of God. But mind is only one of his lower qualities. What kind of a quality "deity" is we cannot tell. But its nature may be assumed to be changing. For the universe is never complete, and new and higher qualities may continue to emerge. So that " deity " is always becoming, always yet to be. But God as the whole universe tending towards deity exists always. And this accounts for the human longing for God, and for communion with him. It is the world with its nisus towards deity that stirs this longing in us. Practical religion consists in doing our part so as to advance the world's progress towards deity, by helping the good to triumph over evil in human affairs. As to the relation of the finite many to the infinite One, " the One is the system of the many in which they are conserved, not the vortex in which they are engulfed."

[*Space, Time and Deity*, London, 1920.]

L. T. Hobhouse ([illegible]) elaborated a philosophy which may be described as a form of evolutionary realism, but which is specially noteworthy for its endeavour to effect a compromise between a number of philosophical antitheses—monism and pluralism, idealism and materialism, empiricism and rationalism. Under the influence of Bosanquet he embraced the view of the systematic or organic function of reason. Immediate judgments are not final. " The basis of rational judgment

lies in the inter-connection of judgments. . . . The whole rests upon the parts and in turn maintains them, and it is this organic principle of mutual support through inter-connection which is the Reason." The speculative reason is the continuous and comprehensive effort towards harmony in the judgments which interpret experience. The practical reason is the same impulse applied to all of our experience that we value. But it is a mistake to assume that the whole somehow explains the parts, without seeking also the explanation of the whole in the nature of the parts which it holds together. This mistake is mainly responsible for the idealist identification of knowledge with reality, in violation of the claim of knowledge to refer to objects beyond itself. " Nothing exists because it is known, but is known because it exists." " Briefly, there is in the nature of knowledge itself no ground for restricting the nature of the known or knowable. What they are must be learnt from the reports of our immediate judgments in so far as their deliverances are reduced to consistency." Knowledge is the correlation both of immediate judgments and of objects, for the interconnected system of judgments asserts a Reality of interconnected objects. This is so, not because objects must adapt themselves to thought, but rather because thought has learnt to accommodate itself to its objects. But the extent of the interconnection of objects must not be exaggerated. We must distinguish between *organic* and *harmonic* unity. There is organic unity wherever there is some degree of both mutual dependence and independence among the parts. The greater the mutual dependence, the greater is the tendency towards harmony ; the greater their independence, the greater are the opportunities for conflict. Now Reality has an organic unity, but is only slowly moving towards the harmonic ideal. Mind with its teleological activity is the tendency towards interrelation and harmony. But in so far as there are also independent or uncorrelated factors in existence, Reality is also characterised by Mechanism. Yet the characteristic process of Reality as a whole is development. And the end of its development is not the peace of death, but the harmony which keeps all things alive. The spiritual power, the principle of goodness that dwells in the world will some day come to its own. Evil is not inherent in the tendencies of things as such, but results from a failure to co-ordinate them. There is no evil principle in the sense in which there is a good principle. And so the world is worth living in, and fighting for.

C. Lloyd Morgan (b. 1852) is largely responsible for what is known as the philosophy of *emergent evolution*. His general attitude is realistic or dualistic. He accepts the reality of a physical world of events interpretable in terms of a four-dimensional space-time frame. These physical events manifest an ascending hierarchy of kinds of relatedness in the case of atoms, molecules, organic cells, and organisms respectively, each succeeding kind involving the preceding. He also assumes a correlation of psychical

with physical events. When certain physical events occur in the cortex of the brain there is consciousness. But this correlation is without a break. There are no physical events, or systems of such events, which are not also psychical events, or systems of such events. There are not two worlds, a physical and a psychical, but one world, which is psycho-physical from top to bottom. What we call " things " are clusters or systems of physical events regarded in abstraction from their psychical correlates. Events come together to form systems of all degrees of complexity. In any such system it is possible to distinguish between its *stuff* and its *relations*. But simpler systems may constitute the stuff of more complex systems. Thus, *e.g.*, electrons are the stuff of atoms, atoms of molecules, molecules are the stuff of a drop of water, and so on until we reach vital events in the cellular tissues which are the stuff of the organism. Each of these systems has its special set of relations, which are called *intrinsic* if within any one system, and *extrinsic* when they interrelate two or more systems. Moreover, these systems are objectively real; they are not carved out of a continuum by our interests. Mind is wholly intrinsic to the individual percipient, but stretches out into the external world through conscious reference to things in that world, which thereby become its objects of reference. This is possible because each receptor pattern has its own psychic sign which is projicient in such a way as to subserve behaviour. In this way the skeleton of independent physical events is clothed with flesh and raiment by the construction of psychic signs projiciently referred to them as the objects signified in perceptual experience.

The world at large consists of (1) physico-chemical events, (2) vital events which occur only in organisms, and (3) mental events which occur only in some organisms. In vital events there is a new kind of relatedness that does not obtain among merely physico-chemical events; and in mental events there is a further kind of relatedness that does not obtain in merely vital events. In other words, vitality is an emergent (or unpredictable) quality of organisms; and mentality is an emergent quality of some animals. But the emergent quality does not supersede the old, it only supplements it. A system of vital events remains also physico-chemical; and a mental system remains also a vital one. But the physico-chemical processes in a living organism are rather different from those in an inorganic one; and the vital processes in a mental system are rather different from those in a merely living one. As a man of science Lloyd Morgan fully accepts its naturalism with natural piety. But if, as a philosopher, he is asked to account for the direction of emergent evolution, he can only suggest that the scientific conception of evolution may be supplemented by the concept of the progressive unfolding in time of revelations of that " Activity " which is universally enfolded *sub specie æternitatis*.

A. N. Whitehead (b. 1861) has taken upon himself the task of repairing the philosophic damage done by his fellow mathematicians. Mainly through the influence of the highly abstract methods of mathematics Nature, so rich in direct experience, has been reduced to something " soundless, scentless, colourless, merely the hurrying of material, endlessly, meaninglessly." Mathematical physicists have taken the cosmic watch to pieces (fortunately in thought only). Whitehead tries to put it together again by means of his " philosophy of organism." It is the ambition of this philosophy to vindicate the reality not only of secondary qualities but of all that contributes to the æsthetic, moral and religious life of humanity, and at the same time to do justice to the legitimate claims of science. The mechanistic tendency of science and its materialism are due to its concentration on abstractions, merely logical entities. Actual experience is always an experience of concrete events. These concrete events may legitimately be analysed into simpler elements or aspects, provided these abstractions are not hypostatised as such, and treated as though they were self-contained realities. The actual events of experience are concrete systems, or " organisms," in which the character of the whole (like the " entelechy " of Aristotle and Driesch) influences the very characters of various subordinate parts, elements or events which constitute it. " Organism," in this extended sense of the term, is a characteristic of all reality, and is not restricted to living organisms. It is a fundamental feature throughout the whole of nature. Physics, according to Whitehead, is the study of the smaller organisms (atoms, etc.), whereas Biology is the study of the larger organisms. Whitehead not only minimises the contrast between the organic and the inorganic, he also rejects the dualism of mind and body. The mind is treated simply as a special organisation of the system of events that constitute the body, and the higher activities rendered possible thereby. But this must not be taken to mean that Whitehead thinks in terms of " substances." Following the trend of recent physics, he takes " events " for his units. The universe consists of events and their interrelations. Events vary in complexity. The larger events are systems of lesser events and eventually of " atomic " events. Reality is thus conceived as a flux, after the manner of Heraclitus, though Whitehead also tries to salvage something of Eleatic permanence by positing Forms, " eternal objects," or universals, somewhat after the manner of Plato. " In the inescapable flux, there is something that abides ; in the overwhelming permanence, there is an element that escapes into flux." Atomic events are called " actual occasions " (also " actual entities"), so that an event in the more general sense is a nexus of actual occasions, interrelated in some determinate fashion in one extensive quantum. What is commonly called a thing or a person is a society of events, or a systematic stream of such events, having a certain causal continuity. Now each actual occasion is related to every other actual occasion in the universe, and so the universe is one compact, organic system of actual occasions, an " interlocked community " of events. And through this mutual interlocking of events it may be said in a sense that " everything is everywhere at all times." The Space-Time continuum is not (as with Alexander) a primitive datum but a construction from the relations between actual occasions. The " interlockings " of actual occasions

are called " prehensions," and are conceived causally. Each actual occasion is generated from its prehensions of preceding occasions, and is prehended by succeeding occasions. The process thus resembles Bergson's conception of the telescoping of the past in the present. In this way each actual occasion attains " objective immortality " in spite of the flux. The " togetherness " of the universe, " the principle of concretion," is identified by Whitehead with God. " God is not concrete, but He is the ground of concrete actuality." " The World is the multiplicity of finites seeking a perfected unity." God is " the unity of vision seeking physical multiplicity." " He is the lure for feeling, the eternal urge of desire," and each creature has its " prehension " into God. " The theme of Cosmology, which is the basis of all religions, is the story of the dynamic effort of the World passing into everlasting unity, and of the static majesty of God's vision, accomplishing its purpose of completion by absorption of the World's multiplicity of effort." But " neither God nor the World reaches static completion. Both are in the grip of the ultimate metaphysical ground, the creative advance into novelty."

G. E. Moore (b. 1873) may be said to have taken up again the fight which T. Reid (1710–1796) waged against the excesses of " the way of ideas." Like his prototype, Moore is a defender of " common sense." Negatively, his main contention is that idealism has not made out its case on behalf of the sole reality of what is mental. There is, therefore, no reason for abandoning the common-sense assumption that there exist material facts as well as mental facts. Positively Moore has done little more than enumerate a series of realistic propositions embodying his own *credo* as well as that of common sense. This may be summed up briefly as follows. (1) There is no good reason to suppose that *every* physical fact is logically or causally dependent upon some mental fact. (2) There are and have been material things. (3) There are and have been many selves. Perhaps rather unlike common sense, Moore does *not* hold that there is good reason for believing in the existence of God, or in human survival after the death of the body. As a philosopher especially interested in the theory of knowledge, Moore is deeply concerned about the correct *analysis* of the propositions which he accepts as true, namely those briefly summed up in (2) and (3) above. What exactly is known when it is asserted for instance, that " this is a hand " ? " Two things only seem to me to be quite certain about the analysis of such propositions . . . namely that whenever I know, or judge, such a proposition to be true, (1) there is always some *sense-datum* about which the proposition in question is a proposition . . . and (2) that, nevertheless, *what* I am knowing or judging to be true about this sense-datum is not (in general) that it is *itself* a hand . . . etc., as the case may be." " In other words, to put my view in terms of the . . . ' theory of representative perception,' I hold . . . that I do

not *directly* perceive *my hand*; and that... I perceive... something which is . . . *representative* of it, namely, a certain part of its surface." But how exactly the representative sense-datum is related to the actual hand he does not know, for he is not satisfied with the various solutions suggested hitherto. Similarly with the proposition " there are and have been many selves." He is certain of its truth, but unaware of its correct analysis.

[*Principia Ethica*, Cambridge, 1903;
Ethics, London, 1911;
Philosophical Studies, London, 1922.]

C. D. Broad (b. 1887) is chiefly known for his Object Theory of Sensa. On this theory there are three entities involved in every perception. First, there are states of mind, called sensations. Secondly, these sensations have objects, called sensa, which are concrete particular existents, like coloured or hot patches, or noises, or smells—the sensa actually having the attributes of shape, size, hardness, colour, loudness, coldness, etc. Thirdly, there are physical objects, the existence of which, and their presence to our senses, we are led to believe in by the existence of the sensa and their presence to our minds in sensation. The properties which we ascribe to the physical objects are always correlated with and based upon the properties of the sensa, but are not always identical with them. When we look straight down upon an object, and the sensum is round, the object itself will also be regarded as round; but when looking at an object obliquely, the *elliptical* sensum may make us believe that the physical object is round. As a rule we are not interested in the sensa as such, but in the physical objects of which they are the appearances. For it is the physical objects, not the sensa, that can help or hinder us in the struggle for existence.

Turning from Epistemology to Ontology, and more especially to the relation of Life to Matter, Broad favours the theory of Emergence. According to this theory there are certain wholes composed of certain constituents in a certain relation, and they are such that the characteristic properties of the whole cannot be deduced from the properties of the components either in isolation or in other kinds of wholes. To understand such emergent wholes it is not enough to know how the parts would behave separately, we must also know the laws of their behaviour when related in that way; and the latter is independent of the former. Such emergence, according to Broad, is already observable in the inorganic world—the knowledge of the properties of elements as such does not enable one to predict the properties of a compound—but is most striking in the case of organisms. There appears to be a general tendency for complexes of one order to combine with each other under suitable conditions to form complexes of a higher order. At each stage there arise things with new characteristics, and at every stage there are new possibilities of further developments. In comparison with Biological Mechanism, the theory of Emergent Vitalism has the advantage that it can dispense with the aid of a Deistic supplement.

The relation between body and mind is, according to Broad, very intimate. Mind acts on body in volition, and body acts on mind in sensation.

If the relation is not described as one of interaction, it is mainly because that word does not express adequately the intimate character of the relation.

Specially interesting is Broad's view of "psychic factors." He finds enough evidence in certain abnormal psychical phenomena to dispose him in favour of the view that the mind is not a mere epi-phenomenon of the body and existentially dependent on it alone, but a compound substance whose constituents are the organism and a "psychic factor" which is not itself a mind, but which may combine with a series of organisms to form a successive series of minds. The psychic factor may exist independently of an organism, and may also combine temporarily with a medium so as to reproduce the characteristics of some dead man whose body it had once animated. On such a view the survival of the *whole* mind of a human being is, of course, excluded.

On the question of the status and prospects of mind in nature Broad's views are not very definite, nor very rosy. Perpetual mental progress is neither impossible nor inevitable. The possibility depends on our getting an adequate knowledge and control of life and mind before the combination of ignorance on these subjects with knowledge of physics and chemistry wrecks the whole social system. "Which of the runners in this very interesting race will win, it is impossible to foretell. But physics and death have a long start over psychology and life."

[*Perception, Physics and Reality*, Cambridge, 1914;
Scientific Thought, London, 1923;

Earl Russell (b. 1872) has described his philosophy as "logical atomism," sometimes also as "neutral monism," as "pluralism," and "realism." It is all these, as will be indicated briefly. To some extent Russell follows the example of British empiricists and tries to analyse our complex experience into its elements or "atoms." But he avoids the mistake made by Locke and his successors when they assumed that a complex whole is nothing more than the bare sum of its elements and of their separate causal efficacies. Russell realises that a configuration may lose its causal properties when broken up into its elements. But he maintains that nevertheless it does consist of these elements related in certain ways, and that is why he calls his philosophy "logical atomism." Now philosophy is not intended to supplant, but only to supplement, the sciences by way of rather speculative suggestions about the world as a whole. And since science and common sense assume the independent reality of a multiplicity of events, things, etc., and there are no convincing arguments to the contrary, Russell feels justified in embracing both "realism" and "pluralism." But what is the nature of the real elements of which the world is composed? Idealism, which describes them as psychical in character, is rejected by Russell, though he admits its possibility. Materialism is rejected even more decisively, especially in view of the present tendency to reduce matter to mere radiation or wave-energy. He prefers to regard the ultimate stuff of reality as neither mental nor

material, but " neutral " in respect of these alternatives. But he thinks that the whole world is composed of only one kind of stuff, namely events. Hence the name of " neutral monism." But this " monism " is not inconsistent with " pluralism," for the monism is qualitative whereas the pluralism is substantival. In other words, although Russell admits only *one kind* of stuff, he also admits the existence of a great multiplicity of events, each minimal event being logically a self-subsistent entity. " The world consists of a number, perhaps finite, perhaps infinite, of entities which have various relations to each other, and perhaps also various qualities. Each of these entities may be called an ' event.' " With regard to the practical problems of life and its values, Russell disparages the homiletic function which philosophy has inherited from theology. " Philosophy cannot itself determine the ends of life, but it can free us from the tyranny of prejudice and from distortions due to a narrow view."

J. E. McTaggart (1866–1925) was a realist in his epistemology and an idealist in his ontology. According to him knowledge is a true belief, and a belief is true when it corresponds to a fact, that is, to something that is something. The relation of correspondence is not a relation of similarity, but it cannot be defined further. Existence and reality are indefinable qualities. What exists must be real, but what is real need not exist. For instance, qualities and relations are in themselves real without being existent, though the qualities and relations of existent substances may be called existent. McTaggart denied the existence of time, of matter, and of sense-data. He held that the universe is spiritual, consisting of selves arranged in one or more primary wholes. The whole content of these selves consists in their perceptions of themselves and of each other. These perceptions have emotional and volitional qualities. The universe has not been created, for what is created must be in time, and nothing is in time. Moreover, the appearances of design in the universe do not suggest a conscious designer as its only possible cause, since a certain amount of order, and a certain direction towards the good, follows from the intrinsic nature of existence.

G. Santayana (b. 1863) is the poet-philosopher of America, though a Spaniard by birth. He is partly a " critical realist," but this does not adequately describe his philosophy. He accepts the reality of transcendent existences. Of these, however, we have no direct apprehension. It is by " animal faith " that we accept their reality although they are not directly " given " to us. What is given to us consists of certain images, notions, surface appearances, or general characters which we refer to the

transcendent existences. All such images, etc., Santayana calls "essences." All the familiar pictures painted by the senses, all the theories of science, and all the doctrines of religion belong to the sphere of "essences." And they can all be regarded as so many compatible, though different, arts of expression of the same transcendent matter. Materialism is a presupposition of conventional sanity; religion is a fairy-tale of conscience. "All is a tale told . . . by a dreamer. . . . Sensations are rapid dreams; perceptions are dreams sustained and developed at will; sciences are dreams abstracted, controlled, measured, and rendered scrupulously proportional to their occasions. Knowledge accordingly always remains a part of imagination in its terms and in its seat; yet by virtue of its origin and intent it becomes a memorial and a guide to the fortunes of man in nature." The whole life of reason is generated and controlled by the animal life of man in the bosom of nature. Human ideas have expressive, symbolic value: they are "the inner notes sounded by man's passions and by his arts"; and they become rational partly by their inner harmony, and partly by their adjustment to external facts and possibilities. The human mind being thus essentially poetical, human wisdom lies in taking everything good-humouredly, with a grain of salt. In any case consciousness, according to Santayana, has no practical effectiveness, being merely an epiphenomenon, a "sort of ritual solemnising the chief episodes in the body's fortunes." The only good accessible to man is the satisfaction to be derived from the sheer exercise of his reason, and in the æsthetic joy that his artistic creations may yield.

General J. C. Smuts (b. 1870) has outlined a philosophy which he has called Holism. By holism he means a tendency to the formation of systemic wholes, each of which is more than the bare sum of its component parts. A whole is not a mere aggregate of parts but has a certain structure (or "form," as Aristotle said) in virtue of which it has greater potentialities than a mere aggregate of similar parts could have. Smuts contends that this tendency to whole-making is traceable in all types of reality, and is the ground of what has been called creative or emergent evolution, which is inconsistent with bare mechanism. Modern science, according to Smuts, furnishes ample evidence in support of holism. Space and time, for instance, are no longer regarded as homogeneous continua, but have been reduced to a curved and warped Space-Time having a definite structure. Matter likewise has been given a precise structure. Chemistry treats the different kinds of substances as the results of different structural arrangements of atoms and molecules; and physics treats the atoms themselves as varying in character with the different structural arrangements of protons and electrons in quasi-solar systems. Matter thus conceived as a system of electric charges is very different from the old inert

matter, and its difference from living protoplasm is considerably reduced. The cell differs from the atom in its greater complexity of structure and function, and in the greater co-operation of its parts, which are made to function for the whole. The same applies even to a greater extent to organisms consisting of multitudinous cells. Just as a " thing " is a synthesised " event " in the system of Relativity, so an organism is a synthesised section of history, which includes not only its present, but much of its past and even its future. The next higher " whole " after organism is Mind. In minds, or psychical organs, the central control is marked by consciousness, and has a creative power of far-reaching character. The highest known whole is Personality, which is characterised by the greatest freedom and creative power.

The world is characterised by both mechanism and free creation. There is mechanism wherever the working parts of an aggregate produce their effects individually, so that the total effect is merely the sum of their separate effects. In the course of evolution holism, with its creativeness, gains on mechanism, and at the stages of mind and personality mechanistic explanation is hopelessly inadequate. But mind, and even life, must not be thought of as new agents. Life, and mind, and personality must rather be conceived as successive advances in the " holistic " structure of matter, involving no disturbance in the prior structure on which each, in turn, is based, each being a creative continuation of the old, not a denial of it. But the inner trend of the universe is directed away from the merely mechanical towards the holistic type as its immanent ideal. The *summum bonum* of holistic philosophy is free and harmonious self-realisation. The holistic nisus of the universe is regarded as a guarantee that the ideals of Well-being, of Truth, Beauty and Goodness are firmly rooted in the nature of things, and are likely to be realised eventually.

[*Holism and Evolution*, London, 1926.]

The foregoing account of recent and contemporary philosophy shows that there is considerable vitality in the philosophic thought of the age. The scoffer may pretend that all these philosophies are little more than the reminiscences of the thought of past ages. He may take to pieces all these philosophical tapestries and show that they are mainly a patchwork of scraps derived from Heraclitus or Parmenides, Plato or Aristotle, Descartes or Spinoza, Locke or Leibniz, Kant or Hegel, Schelling or Schopenhauer. And he may reiterate the oft-repeated charge that there is no progress in philosophy. Such disparagement, however, would be unwarranted, even if we admit some of the points on which it professes to be based. After all, the whole history of civilisation is so short that it has been described as a " provincial episode " when measured in terms of terrestrial time, to say nothing of cosmic time. And of this " provincial episode " the whole history of philosophy is but a single aspect, which only emerged about twenty-five centuries ago, and has been more or less smothered more than half the time. Moreover, the problems of philosophy are peculiarly difficult to answer in a manner that may command general

consent. For they do not lend themselves to the kind of empirical verification which secures something like general agreement in the sciences. In fact, as soon as any group of problems becomes amenable to empirical verification it forsakes its parental, philosophic home, and sets up as a separate science. In this way philosophy always remains the limbo of highly speculative questions, which it is very difficult to answer satisfactorily, but which most intelligent persons find it equally difficult to suppress. And since times do change, and we change with them, each age needs at least a restatement of old problems and old solutions in terms best adapted to its own habits of thought or speech. An excessive straining after originality, or the appearance of originality, may do more harm than good. A knowledge of the history of one's subject is probably a universal requisite, but especially so in the case of philosophy. For of philosophy it is particularly true that all history is contemporary history.

One of the most interesting features of recent and contemporary philosophy is the renewed co-operation between men of science and philosophers. During a great part of the nineteenth century science and philosophy were scarcely on speaking terms. The estrangement was probably rather harmful to both : science became rather materialistic, and philosophy lost something of its realism. The more friendly relationship between philosophy and science is therefore to be welcomed. Yet the change of mind on the part of some men of science is not without its dangers. The pendulum has swung rather hastily from the materialistic to the idealistic extreme. As already suggested, the change is largely due to the new conceptions of matter. The displacement of the old hard impenetrable pebbles by electric charges, or wave radiations, inclines some people to think that matter has lost its materiality and assumed a new spirituality. This reminds one rather of a story told by an eminent ecclesiastic about a young lady who, having strayed so far from the path of virtue as to have a baby, pleaded in mitigation that it was only such a wee little baby ! Matter, however refined, is matter still, not mind. Moreover, some eminent physicists, like J. J. Thomson, do not accept the non-substantial view of matter in its entirety.

Next to the new theories of the nature of matter, the now widely accepted Principle of Indeterminacy has had no little share in converting certain scientists to a religious view of the world. The principle in question is intimately connected with the new views on matter. It has been found impossible to determine simultaneously the energy *and* the position of a particle. This has been interpreted to mean that electrons or particles really have no definite energy and position, both being objectively indeterminate. From this alleged instance of indeterminacy there has been inferred a general Principle of Indeterminacy (or of Uncertainty) according to which, as some would maintain, there is no such thing in the physical world as that causal determination on which the older scientists insisted, and on which the mechanistic philosophy was based. The significance of the Principle of Indeterminacy in relation to free-will and miracles has made a great impression not only on professional theologians, but also on some scientists, who have consequently shown a new interest in theological thought and phraseology. But the precise meaning and significance of the new principle are still in the melting-pot. Einstein

and others regard it as a merely temporary " asylum of ignorance," and expect an early restoration of the principles of rigorous causality within the domain of science. In the meantime, the physicist's reliance on probabilities concerning the constancy of proportions in which atoms undergo certain changes (like disintegration) in a certain time appears to be evidence of physical regularity and determinacy rather than of the play of caprice.

The new scientific speculations, of which but a few examples have been referred to here, have culminated in a certain tendency among some scientists which can only be described as a kind of mysticism. First science is described as nothing more than a system of symbols, and eventually the whole choir of heaven and furniture of earth seem to fade away into a host of bloodless symbols. This whole tendency naturally enough ends in a kind of ontological idealism, the whole universe being reduced, or levelled up, to thought pure and simple. Whether all this is explicitly intended is not certain. One and the same scientist may be found to describe the world, in the same breath almost, as " thought " and as " light "—a combination which rather betrays the obscurity of inadequate reflection. But in any case the real nature of symbolism does not appear to be sufficiently appreciated. A symbol is always a thing of one kind which suggests a thing of another kind. Symbolism, it is true, implies thought, since it is only for thought that one kind of thing can suggest or mean another. But symbolism does not imply the reality of thought only, for unless a material thing really is material it cannot serve as a symbol of anything else. The emphasis so often laid on the symbolic character of science and of nature, though intended perhaps to lay stress on the *significance* of things, ends only too frequently in mystification.

The foregoing considerations may help to explain the unusually friendly relationship which is loudly proclaimed to exist now between science and the Churches. Such an amicable attitude is certainly better for all concerned than was their long-continued antagonism. Yet it is not without its dangers. The history of science makes it pretty clear that science was most fruitful when it followed naturalism as its regulative ideal ; and that it declined, or remained immature or barren, when it came under the influence of theological or mythological conceptions. Let science continue to plough its lonely furrow, as indifferent now to the flatteries of the Churches as it was erstwhile to their frowns. Galileo and Descartes, Boyle and Newton, were deeply religious men (some of them, indeed, almost superstitiously so), yet they took good care to keep their theology out of their science, and to carry on their scientific researches on strictly naturalistic lines. Their example deserves to be followed by other men of science, whose theology is probably much more nebulous than was that of their distinguished predecessors. Let it not be forgotten that the amiable things said by men of science about religion in general may be exploited in the defence of dogmas and practices which they do not approve. In this way the representatives of science may actually obstruct the further advance of the Churches along the paths of progress which, largely under the stimulus of science, they have been following, however slowly, since the days of Bruno, and Galileo, and Servetus. Science owes its wonderful progress mainly to its specialisation, or division of labour.

It is hardly in keeping with the best traditions of science that its representatives should play the parts of popular philosophers and pontiffs. In the early decades of the nineteenth century, it is true, some of the Fellows of the Royal Society of London did perpetrate a series of Bridgewater Treatises "on the Power, Wisdom and Goodness of God, as manifested in the Creation." Nearly a century has elapsed since then, and people still have faith in God and in the Royal Society in spite of those treatises. It would be a great pity if that fact served to encourage many of the present Fellows of the Royal Society to tempt Providence too often. Theologians and philosophers certainly have much to learn from science. Let scientists continue to render the invaluable service of teaching them, by all means—but let them teach science, not philosophy nor theology.

Contemporary philosophy likewise seems to stand in need of an analogous warning. Considering the fact that so many philosophers were formerly students of theology, the relations between philosophy and theology are naturally expected to be friendly. Among British philosophers, indeed, the number of defenders of the faith seems to be abnormally large. It may be that academic conditions, and institutions like the Gifford Trust, either encourage this tendency, or give undue prominence to those who follow it. But philosophy will be in a healthier condition when it has entirely ceased to be a handmaid to theology, and pursues its cosmic problems as independently as possible of vested interests.

AN INTRODUCTION TO ECONOMICS

By

MAURICE DOBB

SYNOPSIS

Economics is most easily defined in terms of the type of question it seeks to answer. The difference between different schools of thought, and particularly between the classical economists and modern economists, mainly consists in the different questions they pose and seek to answer. The Physiocrats first tried to represent the economic system as a unity, having a rational consistency, and regulated by a system of "natural laws." It was the purpose of Political Economy to discover these laws. In this they played the historical rôle of intellectual champions of the new capitalist order. They were principally concerned with the laws regulating "the circulation of wealth," and by discovering these laws sought to establish practical precepts for the action of government in levying taxation and framing commercial and industrial legislation. Their most significant contribution was the conception of "real cost" and of "surplus." Following them, Adam Smith and Ricardo developed the Theory of Value, and elaborated the theory of free competition and *laissez-faire* (or non-interference of government in economic affairs). Marx, however, took the basic conceptions of classical Political Economy, and by enlarging the concept of "surplus" into his concept of "surplus-value" used Political Economy as a criticism of the capitalist system.

In the second half of the nineteenth century economics, with Jevons and the Austrian School, acquired its modern form. The change from the old Political Economy to the new Economics was characterised by a shift of emphasis from cost and supply to demand and utility as determinants of market value. The new theory is frequently termed the Theory of Marginal Utility. But the change went deeper. It represented a concentration on a theory of price, as distinct from the classical concept of "intrinsic value." The theory of price was conceived as a theory of equilibrium; and a mathematical technique was employed. The differences between modern schools of economists mainly consist in the different ways in which they seek to solve this problem of postulating an equilibrium. Certain economists, however, such as Marshall, have sought a synthesis between classical

and modern theory, and have based their theory on a subjective, or psychological, conception of utility and of cost. In this way economics has provided a new justification for capitalism, even while an increasing number of " exceptions " have been admitted to the classical case for *laissez-faire*. But since modern economic theory poses a different set of questions from classical Political Economy, the former is not competent to pass judgment on most of the wider issues with which the latter was concerned. Particularly does modern economics fail to afford any adequate solution of the so-called Theory of Distribution. In the Theory of Money modern economists have made important progress. Possibly the future will see an increasing tendency for economists to develop statistical and realistic studies of particular concrete problems.

AN INTRODUCTION TO ECONOMICS

To define what Economics is about is considerably more difficult than most people think. Economic text-books have provided a number of definitions. " Economics is a study of man in the ordinary business of life." " Economics is a study of those motives and actions which are capable of being measured in money." But such definitions do not carry us very far. In inductive and experimental sciences a preliminary definition of scope is given (at least initially) by the nature of the material, although even here the frontier may be a vague and fading one : for instance, the frontier between Astronomy and Physics to-day. But since experiment in the social sciences is so restricted, Economics is primarily a deductive science, which (like Geometry and Mechanics) deduces a series of conclusions from certain premises or assumptions ; and in a deductive study it is necessarily the development of the concepts themselves which provides its boundaries. In such a case when different schools of thought exist, employing qualitatively different concepts, a satisfactory definition is hardly possible which includes them all. Each may be separately defined, and then the relationship in which each stands to the other may be expressed in terms of something wider. But a final and satisfactory answer can only really be given when qualitative differences have been reduced to a common term, *viz.*, to common differences of quantity or number. This stage, however, is far removed as yet in a field so little charted as the social sciences ; and for the present the most satisfactory way of defining Economics seems to be in terms of the type of question which it asks and seeks to answer, and similarly to define the rival schools of thought in terms of the different questions they pose to themselves or of differences in the type of answer they afford. Much of the confusion which reigns in the field of Economics to-day is, I believe, due to failure to use this simple device. Much barren controversy—for instance between the classical economists and modern economists—has been staged with no issue but stalemate and confusion, because the contestants have failed to realise that each is engaged in answering a different set of questions—Ricardo or Marx, for instance, being concerned with certain aspects of the distribution of wealth between classes, Jevons or Pareto with the conditions of price-equilibrium on a competitive market. Much of the discussion as to the *adequacy* of a certain theory (say of wages or of profits) turns on whether it answers the questions it claims to when those questions are framed with a greater or smaller degree of explicitness. More than one economist has launched his enquiry in quest of answers to certain questions, and then has proceeded to employ an apparatus of assumptions which essentially preclude those questions from receiving any answer.

It is the fashionable view to imagine that the early economists were the crude craftsmen of economic science who, working with inferior tools and

experience, built their structure in an imperfect way, and that their modern successors have retrieved their errors and mistakes in a more finished and completer structure. Ricardo is said to have emphasised "only one side" of the problem (*e.g.* supply, not demand) : to have noticed only one set of the forces at work ; Adam Smith to have laid certain foundations (his enquiry into the causes of the wealth of nations) which needed the improved technique of a hundred years later to complete. Hence the concepts of classical economy are laid against the concepts of twentieth century economic theory and directly compared, to the undoubted credit of the latter for their greater finish and perfection of detail. Where they differ (*e.g.* in their emphasis on cost of production as against utility as determinants of exchange-value), argument is conducted between them as though it were solely a question of differences of answers afforded to the same basic *questionnaire.*

This method of approach is fundamentally erroneous. At best it is a sufficiently partial view of the matter to cause more confusion than enlightenment ; and any further progress in the subject seems likely to be seriously obstructed until an alternative critical approach is tried. It is a commonplace in Art to-day that the "Primitives" of the fourteenth and fifteenth centuries were not merely cruder craftsmen compared to the representational painters of a later date—in many respects they very obviously were not—but that they were trying to do something that was qualitatively different. The Physiocrats and the classical economists are in a sense the "Primitives" of economic science. In some ways they may have had a less finished technique than their twentieth century descendants. But what is more important is that many of the concepts they used were different and that they were trying to answer a different set of questions in a different way : questions partly concerned with the distribution of income between classes, partly with the conditions of maximum economic progress. This fact is obscured because economists of to-day imagine themselves to be answering, and certainly claim to answer, many of the questions which their classical forebears set out to do. But, to a large extent, I believe that the apparatus which they use produces, in reality, solutions which are in fact appropriate to a quite different and more limited context.

THE RISE OF POLITICAL ECONOMY

Political Economy was cradled in those social economic and ideal changes which marked the transition in Western Europe to the new bourgeois epoch. In France and Germany the remnants of feudalism were ripe for abolition. The centre of gravity, economically and politically, was shifting in favour of the *parvenu* "third estate." In England the bourgeoisie had come into its own much earlier, and the bourgeois State, pursuing a commercial policy, had been established two to three centuries before. England had had her economic writers at that period—Thomas Mun, Locke and Sir William Petty—but they were concerned with detailed points of State policy rather than with creating a theoretical system. By the end of the eighteenth century a new section of the bourgeois class was coming into existence : a class of industrial capitalists whose interests

were ranged against the existing system established in the combined land-owning and commercial interests of the eighteenth century Whig aristocracy. But it was in France rather than England that the unified concept of an economic society as the subject for Political Economy first appeared. The French Physiocrats of the eighteenth century sketched the outline which Adam Smith filled out in his enquiry into the *Wealth of Nations*, and Ricardo developed in his analysis of the distribution of wealth.

Both France and England at this time witnessed a considerable ferment of new ideas, couched in the language of natural science, which since Bacon and Descartes was making steady conquests. In antithesis to the old authoritarian order, with its prescribed codes and sanctions, there was placed the concept of a "natural order," which showed its hand only when man was unfettered and free, and which gave its sanctions to the popular will. In antithesis to authoritarian " divine right" was placed the "natural right " of the individual. In was in this framework that there developed the concept of an economic society. This economic society was still in the fœtal stage, taking shape within the confines of a system of sanctions and prohibitions which had at first nurtured and now cramped its further development as an independent entity. Hence, in opposition to the authoritarian views of Mercantilism, which held that a commercial system only existed as such by virtue of detailed regulation by the State and would relapse into chaos without such control, Political Economy offered the conception of an economic order ruled by ".natural law," which would " go by itself " if left to itself and would only produce the best results if " natural law " were left to operate free and unfettered. The individual had a " natural right " to pursue his own self-interest, because in so doing by virtue of this " unseen hand " he thereby promoted the common good. To discover and postulate this " natural law " was the rôle of Political Economy ; and " the advice to the sovereign " which it tendered was not how to regulate, but why not to regulate, economic affairs in order to promote the greatest wealth of the nation. And while the Physiocrats coined the slogan *laissez-faire*, *laissez-aller* (let do as you please, let go as you please), the English economists followed Adam Smith in expounding that imposing symmetry of economic harmonies which would come to birth if it were not suffocated and strangled by an unnatural degree of obstetrical attention. Political Economy, therefore, had its origin and derived its force as a direct apologetic of capitalist individualism.

An economic order ruled by " natural law " must possess a unifying principle. However complex and apparently arbitrary the phenomena, they must be explicable in terms of generalisations which hold together in a consistent logical whole. Science is not a matter of classifying everything in an arbitrary arrangement of pigeon-holes, or fitting it into a convenient card-indexing system, even if this be a necessary preliminary device. Its ultimate aim is to refer the maze of qualitative differences which meet the eye to a single common denominator. The Physiocrats were the first explicitly to conceive of the economic order in analogy with a natural organism ; and the dominant analogy which presented itself was that economic society was a system of the circulation of wealth. What was

the physiology of this process? The economic system was to human society what the body was to the human personality—the physical basis for the growth of the higher functions; and the condition of social progress was that the economic system should be capable of yielding to the State and the ruling class the largest possible surplus on which the development of the State and of culture could thrive. Quesnay's famous *Tableau Economique* was designed to show how of the annual produce part went by exchange to replace what had been consumed during the previous cycle, another part did not need to go back into the economic system as a condition for restarting a fresh cycle of production and circulation over again, but remained as a *surplus* or *produit net*; and labour was judged " productive " to the extent that it yielded such a surplus. What commerce and manufacture absorbed was what was necessary as fuel to their activities. Manufacture exchanged the products which it did not use itself against the agricultural production which it required to supply its raw materials and the subsistence of its work-people. Manufacture by this act of exchange did no more than give an equivalent for equivalent received, and hence was not productive of any surplus. Said Mirabeau: " I give a length of cloth to a tailor: he will never be able to increase it, so as to make out of it a coat for himself as well as for me." Agriculture, on its side, exchanged a part of its products against manufactures which it needed for the maintenance of agriculture and the agricultural population, such as tools and clothing. But this part of its produce which it exchanged against manufactures, *plus* what it used itself for subsistence and seed-corn, did not exhaust the whole of the produce of the land: a third part went to the landowning class as rent, without any exchange of equivalents. This was the essential surplus, or *produit net*, of the economic system; and agriculture alone yielded this surplus. Progress consisted in the continual enlargement of this *produit net*.

These ideas have been so often misunderstood by later economists, that the Physiocrats are frequently assigned only a modest place in the hierarchy of political economy. Economic text-books customarily pass them by with a reproof for being so stupid as to assert that agriculture alone was " productive," thereby missing the essential definition of " productive " as creative of surplus or *produit net*, and missing, too, the whole fundamental significance of the distinction between surplus and gross produce and cost, as the unifying concept of political economy. And in tracing this surplus to agriculture alone the Physiocrats were asserting nothing so silly as their traducers claim: it was a concept born from, and appropriate to, economic society before the French Revolution, when manufacture on a capitalist basis was still in its infancy and land rent was the essential basis of the income of the ruling class. In the history of ideology it represents an interesting transitional philosophy lying between the old epoch and the new. Formally, by its insistence on the importance of agriculture and of land rent, it seemed to rest upon the aristocratic society of the past. Certainly it contained no prophecy of nineteenth century industrialism or of the needs and functions of a new bourgeois class. Indeed, what grounds for such ideas were there in eighteenth century France? But in its implied insistence on removing feudal restrictions on agricultural development and restrictions on

capital investment in farming, in its emphasis on freedom of commerce and on land rent as the appropriate basis of taxation, in its concept of a "natural" economic order which would "work of itself" unaided by authoritarian control, its significance was revolutionary. In the realm of economic ideas, it played the same rôle of John the Baptist to the coming bourgeois revolution that Voltaire and Rousseau played in the realm of political ideas.

Adam Smith (1723–1790), who was considerably influenced by the Physiocrats, was much more concerned with composing a commentary on specific economic questions and in advancing a practical thesis than in establishing a conceptual unity. In this he was fully in the tradition of English empiricism. At the same time, his treatment was more comprehensive in the range of practical issues he touched upon, more thorough in its detail, and his championing of the new bourgeois philosophy of economic freedom was much more explicit. His enquiry into the causes of the wealth of nations produced a number of sound empirical generalisations about the division of labour and the accumulation of capital, a vigorous criticism of Mercantilism, and an acute analysis of the effects of different forms of taxation. Temperamentally he differed considerably from the Physiocrats, at any rate from Quesnay. His empiricism even had a touch of atomism about it. He was at any rate quite willing to be eclectic where convenience seemed to demand it. The only considerable point of doctrine on which he differed from the Physiocrats was in their statement that agriculture alone was "productive"[1]; but true to his temperament he left the matter there and developed the concept of a *produit net* in manufacture no further. Ricardo (1772–1823), on the other hand, whose essentially continental temperament was in many ways the antithesis of that of Adam Smith, was much more in the direct tradition of the Physiocrats (*i.e.* in the manner of his approach, and in his method, rather than in his conclusions). He was concerned to establish a unitary principle by which to interpret all the major phenomena of the economic system. In particular, he was concerned, like the Physiocrats, with the problem of the distribution of wealth. In his treatment *produit net*, or rent, assumed specifically the garb of an exaction from the industrious classes for the benefit of the passive landowning class. This was an important shift of perspective. In his theory of Profit he virtually advanced a second species of *produit net*—an implication which Marx was quick to develop—the *produit net* of manufacture. But this species had essential peculiarities, even if it belonged to the same broader genus. As it represented the income of the bourgeoisie, the accumulators of industrial capital and the pioneers of industrial advance, its increase constituted a desirable engine of progress, whereas rent, which fed a passive and reactionary aristocracy, was a tax on progress. Ricardo was *par excellence* the economic prophet of the industrial bourgeoisie.

THE THEORY OF VALUE

The Physiocratic analysis clearly turned on the distinction between surplus and cost and on the notion of equivalence. In Quesnay's circulation process the actual equivalence established on the market in the

exchange of one commodity against another was taken for granted. But such a market equivalence was not a stable thing : cloth did not retain an invariable value in terms of corn, but changed from year to year, even possibly from week to week. What was the secret of such changes ? Was there some fundamental, some " natural " basis of equivalence which market value might not always adequately express ? Was there a sense in which corn might sell above its value and cloth below it ? If so, might not a concealed surplus lie behind the act of exchange ?

Such considerations led directly to the search for a theory of value, which became the primary concern and the essential framework of classical Political Economy. Preoccupied with ideas of " natural law," the political economists came to conceive of a " natural value," or principle of economic equivalence, which was not necessarily synonymous with actual realised " market values " and would only be completely realised on the market in a " natural order "—the ideal *laissez-faire* individualist system. And since such a value was a principle of " natural law," it necessarily had something essentially proper, just and harmonious about it. Just as natural science dealt with such properties as " length " and " weight," it seemed that economic science ought to be able to base itself on the basic fact of " value." " Intrinsic value " was commonly distinguished from " extrinsic value " (or actual exchange-value). Petty (1623–1687) used the interesting distinction between " Natural Cheapness (which) depends upon the few or more hands requisite to produce the necessities of nature, as corn is cheaper where a man produces corn for 10 than where he can do the like but for 6," and " Political Cheapness (which) depends upon the paucity of the Supernumary Interlopers into any trade over and above all that are necessary." Much effort has subsequently been expended in demonstrating that the classical economists were confused when they spoke of a " measure of value," by which they sometimes meant the " cause of value " and at other times the measuring rod (be it corn, or labour or gold) in which value was expressed. Probably they did not analyse their concept very deeply ; it is easy in language, and consequently in thought, to confuse, say, length, or spatial extension, with the conventional foot, yard and furlong measures. This confusion, however, was not very serious to their reasoning ; and the criticism neglects what was the essence of their point of view. The thing, the quantity, which constituted the " intrinsic value," in so far as it could be separately abstracted, *ipso facto* constituted an invariable measure of " value " too ; just as a pound weight constitutes weight, and measures it at the same time. But the confusion of which the earlier economists definitely were guilty was between cost and value. It was distinctly tempting to identify the two : the distinction between gross produce and net produce turned on the concept of a cost which consisted in what was " necessary " to keep the productive system working—the essential fodder to the economic machine. In each cycle of production a certain amount is put into the economic system—seed-corn, subsistence for the workers, etc. In the course of the productive cycle enough is yielded to replace this original cost or outlay, *plus* something in addition—the *produit net*. So long as this process is conceived in terms of a single composite commodity, corn, as it was with Sir William Petty and to some extent with the Physiocrats,

the concept was an easy one. The real cost of a thing consisted in the outlay of corn necessary to finance its production, and it was a reasonable step to assume that this constituted the " natural value " of a commodity.[1] But as soon as one included other commodities than corn in " necessary " subsistence, the simplicity of the explanation broke down : one was involved in the circular problem of first establishing the equivalence of the various commodities (say corn, meat and cloth) which constituted cost. To resolve this difficulty, a transition was accordingly made from the corn necessary to feed labourers to the actual labour as constituting the fundamental " cost " and the basis of " natural value." Labour was essentially the creative agency in all production, the *sine qua non* of converting what nature offered into the actual requirements of man. The " real cost " to mankind of winning a livelihood consisted in the amount of labour it was necessary to expend ; and it seemed " natural " that different commodities should be estimated or valued in proportion to the labour their creation required.

But the earlier idea of cost as " subsistence " still remained to sow confusion. From the standpoint of an employer and the employing class as a whole, " cost " in the last analysis consisted in the outlay of subsistence for workers—the necessary condition of production. What the workers returned to him by their efforts over and above this constituted for the employing class the net produce of the system—the source of profit on capital. Marx was the first to point out this confusion when he charged Ricardo with confusing labour as the basis of value (the actual quantitative expenditure of effort) with the wages paid to labourers (the value of their labour-power).[2]

When Ricardo sought to show that in a " natural order " commodities tended to exchange at their labour equivalents, he did so on the assumption that competition would tend to establish a single level of wages (for labour of the same quality) and a single level of profits throughout different lines of production. Since the relative amount of wages expended, say, to produce a yard of cloth and a bushel of corn would be proportional to the labour employed, and since the profit, being the same rate on capital outlay in the two cases, would be proportional to the outlay in wages, it followed that the relative values (wages plus profit) of corn and cloth would be proportional to the labour involved in their production. Summarily, his argument amounted to an identification of money cost and real cost : market prices would be proportional to money costs (wages), and money costs proportional to labour expended.

This coincidence of normal market value with labour value applied so long as fixed capital, embodied in machinery and buildings, bore the same ratio to capital laid out as wages in all industries. But this is clearly not so : in agriculture or watch-making the ratio of labour to machinery

[1] For this interpretation of classical doctrine and for several other ideas which follow I am indebted to Mr. P. Sraffa, of Cambridge.

[2] The assertion frequently made that Marx was a man of hasty reading and understanding, who based his theories on one or two imperfectly understood ideas of Ricardo, is quite contrary to the fact. One need only read the very detailed and acute analysis of the Physiocrats, Smith, Ricardo and several less-known economists in Marx's *Theorien über den Mehrwert* (almost unknown in this country), to realise the absurdity of the assertion.

will be relatively high ; in iron or cotton production the ratio will be relatively low. Ricardo mentioned this as an " exception "—in his first edition as an exception of minor importance, insufficient to invalidate his general principle, in his third edition admitting it as a more serious modification of his theory. And a serious modification it certainly was. For, to the extent that the ratio between machinery and labour varies, commodities will actually exchange on the market, not in proportion to the labour expended to produce them (including the stored-up labour embodied in the machinery), but some at a higher value and some at a lower. Where a relatively large amount of capital is locked up in buildings and plant, the need for this capital to earn a normal rate of profit (otherwise it will eventually migrate elsewhere) will require these commodities to exchange at a higher value against commodities produced with less machinery. The coincidence between labour values and market values breaks down : if labour constitutes the fundamental " real cost," then the equivalence which the market expresses is not this more fundamental equivalence. Instead, market values = wages *plus* normal rate of profit on the capital employed.

RICARDO AND RENT OF LAND

But what of rent of land ? Did rent arise because agricultural commodities exchanged on the market at a higher value, relatively to their labour equivalence, than manufactures ? Did it arise because agricultural values equalled not only wages *plus* a normal rate of profit on capital employed, but wages *plus* profit *plus* rent as well ? In other words, was rent extracted because exchange on the market between agriculture and industry caused the former to give less than an equivalent for what it received in exchange ? Ricardo formally answered " No " to this question by an ingenious analytical device. How, indeed, could he admit the inconsistency of a " natural order " producing " unnatural " exchange equivalents ? But the answer was entirely dependent on the ingenuity of the device, and not independent of it. This device was the concept of the differential, so dear to the economist heart ever since. Rent arose because of differences in the fertility of different soils. As the market for corn expanded, the more fertile soils being fully tilled, cultivation extended to inferior soils where the expenditure of labour required to produce a bushel of corn was greater than on the superior land. The value of corn was determined by the labour expended at the margin of cultivation, *i.e.* under the least favourable natural conditions. But since the price of corn in the market equalled the cost on the inferior land, the corn grown on the better land, where the cost per bushel was less, yielded a surplus. This constituted economic rent and accrued to the landowner : directly if he was both owner and cultivator, indirectly through the competition of farmers for the better land if the owner leased to a tenant. Rent therefore figured as a product of Nature's bounty, which the landowning class was able to annex as attribute of its right of ownership. And as the progress of society increased the valuation placed upon these scarce qualities of nature, resort had to be made to less and less fertile soils, the margin of cultivation was extended, and rent tended to rise. With the march of industrialism

wages would tend to remain at, or near, subsistence level (owing to the law of population and the competition of labourers for employment), the rate of profit (with the progressive accumulation of capital, fall of price and rise in cost of agricultural production) would tend to fall, and at the same time rents would tend to rise.

The exclusion of rent from the problem of market value—excluding it as a price-determining element with the dictum, which has sown so much confusion, " that rent does not enter into cost of production "—was entirely formal. It was a trick of analytical framing, a trick of definition, the simplest of tautologies, and nothing more. If price equalled cost at the margin, then rent had nothing to do with it, for the simple reason that rent did not appear at the margin. But it still remained true that, if one spoke of the *average* cost of producing agricultural products, rent arose because a *smaller* quantity of cost-equivalents was yielded by agriculture in market exchange against a given cost equivalent yielded by manufacture. In other words, rent arose because the price of corn was raised *above* the *average* cost of producing that corn But there was this much to be said for the Ricardian tautology : the reason for this raised agricultural price was the limitation of natural resources and was not the work of alterable man-made institutions or man-made restrictions. The landlord, as owner of scarce natural properties, was a passive not a deliberating agent in the process ; and the emergence of rent was consistent with and not a violation of, a " natural order " of exchange-, or value-, ratios

But Ricardo was less concerned with the *qualitative* characteristics of rent and profit than with the factors which influenced changes in them, and with emphasising the class antagonism which lay between them. And here he was most conspicuously champion of the new industrial order. His theory of rent as a surplus at the expense of the industrial classes, and a tax on their income, was heavy theoretical artillery against the landowning interests and against legislation, such as the Corn Laws, which by raising rent lowered profit. He was the bourgeois economist *par excellence* because he presented, more explicitly and fully than anyone before him, the " natural economic order " as a conceptual unity, and presented progress as essentially consisting in the process of capitalist industrialisation. And with him bourgeois Political Economy reached its zenith. His immediate followers did little more than repeat and elaborate his ideas. J. S. Mill (1806–1873), for all his undoubted qualities, was an essentially cautious and unoriginal mind, which played the rôle of careful editor, commentator and interpreter to Political Economy, rather than an inventor of new ideas.

AFTER RICARDO

The most significant characteristic of classical Political Economy after Ricardo has usually been treated as a marked improvement. Certainly it followed as an attempt to avoid the *impasse* which Ricardo had reached in his attempt to identify market values with real cost. Viewed in correct perspective, I believe, this is to be regarded as a symptom of decline, since it constituted, in effect, an abandonment of the most fundamental part of the problem which underlay the Physiocratic enquiry and a passing over into empiricism and eclecticism. The attempted solution was really

no solution, but a retreat from the issue. It consisted in virtually abandoning the conception of objective real cost. " Real cost " was retained in name, but was given an altered content which was sufficient to change and to destroy its essential significance. Adam Smith was first responsible for importing the phrase " toil and trouble " into the problem of real cost. But when he referred to labour as the basis of value, he seemed more frequently to use it in the original objective sense of concrete material expenditure of human energy than in any subjective psychological sense. With Ricardo's successors and interpreters, the conception of real cost became explicitly and completely shifted on to a subjective basis. McCulloch had defined " real value " as regulated by the " quantity of labour required " ; but at the same time he seems to have defined Smith's " toil and trouble " as measured by " the sacrifice to those by whom it [the labour] is performed."[1] And after him " real cost " became explicitly something psychological—a disinclination, or *malaise*, in the mind. Given this shift of content, the logical next step was Senior's " abstinence," or refraining from present consumption in order to save and invest, as a second category of real cost, this " abstinence " affording the " explanation " of profit and removing it from the category of a surplus. Real cost = labour + abstinence. Money cost and price = wages + profit. *Therefore*, market values coincide with real cost. The Ricardian dilemma seemed to be solved. But the solution was no solution. Once the unitary conception of real cost had been abandoned, the possibility of using it as a concept of equivalence between commodities necessarily broke down : to enquire whether or not things exchanged in the market on the basis of these equivalents became otiose. One now had two dissimilar so-called quantities—" labour " and " abstinence "—qualitatively different. How to equate them to form a single quantity, real cost ? Was an hour of labour to be equated to an abstinence from the enjoyment of £1 for an hour, or for a day, a week or a year ? " Real cost " remained merely as a catalogue-device to embrace two disparate categories which could only be equated in terms of money—*i.e.* in terms of their market values, which were themselves dependent, of course, on the market values of the latter. If the former reflected the latter, how could they be based on the latter ? What meaning had enquiries about the identity of the two ? Perhaps a Hedonist psychology (which explained human behaviour as motivated by calculations of pleasure and pain) could afford a solution by reducing both " abstinence " and " work " to terms of a single quantity—" Pain." But this solution, though it was suggested, was never very explicitly defined. If it had been, the concept of sacrifice would probably have had to be shorn of much of the meaning generally imparted to it. At any rate, it is highly questionable whether any such solution would find acceptance to-day. As it was, Senior had considerable difficulty, I believe an insuperable difficulty, in delimiting his concept of abstinence. Was there a " sacrifice," or " real cost," involved in lending property that was inherited, as well as in lending property that had been accumulated out of one's income ? If so, where was the difference between lending a factory or a railway and lending land ? If not (as Senior decided), why so arbitrary a boundary to the virtues of sacrifice ?

[1] J. R. McCulloch : *Principles of Political Economy* (1825), pp. 215–217.

So long as real cost meant "sacrifice," there seemed no solution: one cannot sacrifice unless one has something to sacrifice; and sacrifice becomes simply a "function" of available opportunities, variable with those opportunities and constituting nothing fundamental at all. The search for a theory of value became merely an empirical one—a collection of the various proximate causes of changes in market price—which could afford no judgment as to the "natural" fitness, appropriateness, desirableness or otherwise of the system of exchange equivalents which the market established. Moreover, once an adequate system of real cost was gone, there was no basis for any fundamental distinction between gross and net produce: the concept of surplus no longer had a consistent meaning.

MARX AND SURPLUS-VALUE

The tradition carried down from the Physiocrats through Ricardo passed not to Ricardo's direct descendants but to Marx (1818–1883), who took the Ricardian system, sheared it of its "natural law" framework, and revolutionised its qualitative significance. Marx was remarkable precisely for these features of his work, which have most rarely been appreciated; but set against the background of the type of questions which classical Political Economy was concerned to answer, his system can justly be said to have crowned the classical edifice. Certainly Marx crowned it in a peculiarly Hegelian way: in the manner in which he claimed in his philosophy of history to have turned Hegel upside down—to have stood him on his feet where he found him standing on his head by substituting a materialistic interpretation of history for an idealistic one.

Marx did not start from the concept of natural order underlying the capitalist system; for him capitalism did not constitute the final term of economic progress, but was historically relative and transitional. Hence he was biassed by no desire to identify market prices with real cost. Labour in an objective sense—the expenditure of human energy of muscle or nerve—constituted value, that is the social valuation to be placed on the commodities which were the fruit of this labour. It was the fundamental equivalent, the criterion by which one could judge the significance of the price relationships established by the market under varying sets of conditions. Without it there was no ultimate criterion. One could not say whether a certain act of exchange represented a passing of equivalents or not; and hence without it the Physiocratic concept of "surplus," as something which accrued without any equivalent being absorbed in return, would have no meaning. Under certain sets of conditions,[1] market prices would coincide with values. Exchange would be of equivalent for equivalent; but by no means under all sets of conditions. It is precisely in the failure to appreciate this that the monstrous misapprehensions which affected nearly all Marx's subsequent critics consist. Marx never identified market value with labour value, as Ricardo tried to do. How then could there be a "Great Contradiction" when Marx, in vol. iii. of *Capital*, developing what Ricardo had admitted as an

[1] *e.g.* what Marx, a little obscurely, termed "a society of simple commodity production" in vol. i. of *Capital*.

" exception," specifically stated that under conditions of modern capitalism commodities did not exchange at their values, but at what he called their " price of production ? " This latter quantity equalled wages *plus* a normal rate of profit on the capital employed, and diverged from " value " to the extent that the ratio of machinery to labour—what he termed the " organic composition of capital "—varied in different lines of industry.

Marx's problem was to determine the distinguishing characteristic, the social significance, of capitalist profit. If it was a surplus in the Physiocratic sense of values paid to someone without a giving of equivalents in exchange, how did it arise and on what conditions did its emergence depend ? His method was to take a " simple commodity society," where commodities exchanged at their values (avoiding the complication of different compositions of capital), and to enquire how a surplus could arise on such assumptions. It could not arise in the course of exchange, because this was an exchange of equivalents. The answer he gave was that it arose from the peculiarity of labour-power as a commodity in producing more commodities than were used up to produce the original labour-power—used up in the subsistence necessary to replace the energy expended. Labour-power produced a value greater than its own value. The capitalist purchased labour at its value ; and this constituted for him the primary expense of production. The value of labour-power was itself determined by the amount of labour required to produce it—that is, by the subsistence necessary to maintain the worker in working efficiency under any given set of social conditions and at any given time. The capitalist was able to annex, as his profit, the difference between this (*viz.*, wages) and the gross value which labour, when set to work, produced. Wages were the payment of equivalent for equivalent—subsistence for the worker replacing the energy he expended in his employer's service. Profit, in contrast, arose from the peculiar quality of the commodity labour-power that, when put to use, this labour created a value greater than its own value—profit arose from an exploitation of the difference between the value of labour and its product. Hence its qualitative peculiarity, which he characterised by the term " surplus value " ; hence a class antagonism between receivers of surplus value and the producers of it, which in our own day is more significant than Ricardo's antagonism between landlord and capitalist.

But labour-power only figured as a commodity, bought and sold in a labour market, under a definite set of historical conditions—when historical processes had created a propertyless proletariat without other means of livelihood, on the one hand, and a propertied class on the other hand. The emergence of profit, therefore, was not a " natural " category rooted in a natural order of things : it was a category of income peculiar to a particular stage of historical institutions, to a particular form of class society.

In the later stages of his analysis Marx introduced the conditions which caused market prices to diverge from value-equivalents. Chief of these was the need imposed by the competition of capitals for profit to be spread out so as to yield an equal rate per £, as water finds a common level given a sufficiency of connecting pipes. This caused commodities, which had

been produced with a relatively large proportion of fixed capital to labour, to sell above their value-equivalent, and commodities which had been produced with a relatively small proportion of fixed capital to labour, to sell below their value-equivalent. But this divergence was not of a kind to invalidate his central theorem—to upset the character of profit as surplus-value. It effected an altered distribution of this surplus between different lines of industry and altered proportions of production in different lines; but it did not affect the size of surplus-value in the mass.

THE NEW ECONOMICS

In the last three decades of the nineteenth century Political Economy underwent an important change, which has a different and a deeper significance than is customarily realised. Simultaneously and independently the so-called Austrian School, on the one hand, with Menger, Boehm-Bawerk and Wieser as its giants, and Jevons in England, were building the new frame-work within which Economics (to use Jevons' new term) has moved ever since. Closely on their heels followed Marshall in this country and Walras and Pareto, of the so-called Lausanne School, on the Continent.

At first sight the change seems mainly a formal one. The new school of thought has frequently been referred to as the school of Marginal Utility to describe the two most important features of the new theories. The first noticeable difference between the old economists and the new consisted in an important shift of emphasis from supply and cost to consumers' demand and utility as the determinants of exchange-value. Value was no longer regarded as determined by labour, or even by labour *plus* abstinence, but by the capacity of a commodity to afford satisfaction to consumers (*i.e.*, its utility). This represented a psychological and Hedonist approach to the problem from the standpoint of consumers' desires. The second feature of the new theories was their emphasis on the effect of changes at the *margin*—for instance, the loss or gain of utility resulting from "a little less" or "a little more" of a certain commodity (say, cloth or corn or tea); and it was the utility of "a little less" or "a little more" (the *marginal utility*) which was regarded as important in the determination of value. This emphasis on the margin was the result of an attempt to construct economic science in a mathematical framework. Jevons (1835–1882), for instance, was at considerable pains to prove that economics must be a mathematical science in *form*, whether the economist actually spoke in words or in algebraic symbols. He accordingly employed the mathematical conceptions of the differential calculus and of functional equations as a convenient analytical technique; and since the differential calculus deals in terms of small increments and decrements (of "a little more" or "a little less" of something or other), economists tended to frame their theories in terms of marginal changes of this kind.

But the change went deeper than this: it was a change of conceptual approach, and a change in the type of question that was being answered. The new economists were not concerned primarily with conceptions of "real cost" and "surplus"; they were not concerned with a principle of intrinsic value as a key to the problem of equivalence. They were concerned with a more empirical enquiry—the causes of changes in

market values. This enquiry bounded their horizon so far as the theoretical core of economics was concerned; and all the major economic problems could be reduced to these terms. It was natural that, in pursuit of such an enquiry, the analogy of a theory of equilibrium should be suggested from mechanics. " Value " represented a certain " position " or " level " which, in equilibrium, a commodity occupied relatively to the remainder of commodities. In this sense " value " was always a " relative " value; and the concept of " absolute value " as a sort of " fixed star " in the economic universe was meaningless. The purpose of economic theory was to postulate the series of equilibria which would result under various possible sets of conditions; just as a theory of mechanics enables one to calculate that, given a collection of forces at work in a certain arrangement, things will come to rest in a certain equilibrium position. But, as everyone knows who has ever played with a collection of pulleys or thought about the structure of a suspension bridge, it may not always be possible to calculate a " stable equilibrium " where opposing strains and stresses balance one another; while in certain very complicated situations one may not know enough of the facts to be able to calculate what the new equilibrium will be, if one starts a movement by displacing one of the forces at work. To be able to calculate an equilibrium, therefore, the situation one is dealing with and one's knowledge about it must fulfil certain conditions. Whether these conditions are fulfilled or not is the criterion by which one judges whether a theory of equilibrium in economics, as in mechanics, is *adequate* or not.

The attempt to calculate an equilibrium in a given situation is comparable to the familiar attempt in algebra to " solve " a system of simultaneous equations. In these equations there are a number of " unknown variables " (usually written as x, y, z, etc.) and a number of " constants " (usually written as a, b, c, etc.). About the former, it is assumed, one knows initially nothing at all. The latter are part of the given *data* of the problem : some particular value, or number, is, or can be, assigned to them ; and the actual arithmetical " solution " of the equations will differ according to the value assignable to these " constants." The " solution " consists in " determining " (or finding the value of) the unknowns (the x, y, z, etc.). A simple rule exists as to whether a system of equations is capable of being solved : it has a solution if *the number of equations (or known relationships) is equal to the number of unknown variables which have to be determined.* And this is the criterion of whether a theory of equilibrium is " adequate " or not.

Economic theory has employed the conception of " functional equations " (one quantity is expressed as a " function " of another if the one varies, or moves, with the other in some particular way). Moreover, it has employed functional equations of an " arbitrary " or general type, which merely postulate *some* functional relationship between quantities, and not any *one particular* relationship. By this means it has made its conclusions of a more general character—a given theory is made to cover a wider range of possible cases. For instance, economic theory may assume that consumers' demand for " a little more " of x will decrease with the quantity of it that is offered for sale, but without specifying the precise nature of that variation of demand ; and in this way x can be taken to represent

a wider range of particular cases (*e.g.*, corn or cloth or tea or gramophones or labour).

In the new economics, therefore, it was no longer a question of searching for a single " cause " of value, a primary constituent or principle to which all questions of exchange and distribution could be related. There was no longer a need (at any rate for the theory of value as now conceived) to analyse everything into terms of what was virtually a single factor of production—a common term of real cost in relation to which qualitative differences could be resolved. It was a question of grouping together certain functional relationships, all of which, in combination and " simultaneously," determined value. It was a matter of pure convenience how many factors of production there were, provided only one could make sufficient assumptions about the supply of them. All that was necessary was to be able to postulate a sufficient number of conditions and to find the right number of independent variables for a determinate equilibrium to be established. In the search for these independent factors Jevons and the Austrians transferred their attention from conditions of production to consumption, from supply to demand, and sought the important determining factor in what underlay consumers' demand. And here Hedonism gave them an important clue. Consumers' demand was a reflection of consumers' desire; and desire, in turn, (at least in rational men) was rooted in the pleasure which the object of desire afforded. This capacity of affording pleasure Jevons termed Utility. The earlier economists had indicated that value could not be a function of utility, since some commodities, like water, had a high utility but little or no value, and others, like diamonds, had small utility but high value; and Marx had pointed out that utility was not a quantity and could not therefore bear a relation to a quantity value. The discovery which Jevons and the Austrians claimed to enunciate was that price was a function, not of aggregate utility (which it obviously could not be), but of the *increment of utility*—of the additional utility afforded to the consumer by the marginal unit of a given supply.

For instance, of a given supply of fish offered for sale on a market on a particular day the marginal utility of the supply of fish would be the utility to some consumer or other of the *n*th or final lot of fish sold. (By *n*th is meant, that, if there are 100 fish, it is the hundredth; if 1,000 fish, the thousandth, and so on.) Price could not be greater than this (if the fish is marketed at a single price), otherwise the final lot of fish would not find a purchaser who thought it worth while (as measured by its utility) to buy more fish at this price; while on the other hand the seller of fish, desiring to get the highest price he could, would presumably not part with his fish at a price appreciably below this. Whether utility itself was a quantity or not, this marginal increment of it was capable of being expressed in quantitative form. Jevons said: " Repeated reflection and enquiry has led me to the somewhat novel opinion that value depends entirely upon utility. . . . Labour is found often to determine value, but only in an indirect manner by varying the degree of utility of the commodity through an increase or limitation of the supply.[1]

The starting-point of the new theory was an empirical observation

[1] W. S. Jevons: *Theory of Political Economy*, (1871), pp. 1–2.

about the nature of desires, which has been variously described as the Law of Diminishing Utility or the Law of Satiety of Wants. The utility of a thing would generally increase with the amount of it possessed and enjoyed, but generally at a diminishing rate, the increment of utility afforded by an increment of supply tending towards zero at some near or distant point—the point of satiety. It was this increment of utility at any one point—"the final degree of utility," as Jevons called it, or "marginal utility," as Marshall termed it—which determined value, since this fixed the worth of a little more, or a little less, of the thing to the person in question, and so determined the rate at which he was willing to exchange it against something else—against money or other commodities. For instance, suppose two persons A and B exchanging corn against cloth. One could express the utility of corn and of cloth to each of the parties as some function of the respective quantities of corn and cloth possessed. The seller of corn will find it in his interest to continue to give corn in exchange for cloth up to the point where the utility of the bushel of corn he is parting with is equal to that of the quantity of cloth he obtains in return; and similarly for the other party. Hence the position of equilibrium—the point where exchange between them will stop—will be that rate of exchange where the marginal utility of corn and cloth is equal for each of the two parties. Hence, given this condition and the form of the utility function for the two parties, a determinate equilibrium—the amount of corn and cloth exchanged—can be calculated. Expressed symbolically in terms of two commodities *a* and *b*, we have the following conditions of equilibrium :—

$$\frac{\phi_1(x_1)}{\psi_1(y_1)} = \frac{x}{y} = \frac{\phi_2(x_2)}{\psi_2(y_2)}$$

where $\phi_1(x_1)$ and $\psi_1(y_1)$ represent the utility-functions of *a* and *b* to A, and $\phi_2(x_2)$ and $\psi_2(y_2)$ the utility-functions of *a* and *b* to B. In graphical form the relation between the pair of utility-functions to A can be expressed as a curve, and similarly for B; and the equilibrium will be represented as the point of intersection of the curves.

In this problem there are two equations and two unknowns, so that the equations yield a determinate solution.[1] Some economists have been quick to point out, as a corollary of this reasoning, that this equilibrium-rate of exchange, which the conditions of a free market tend to establish, is that which gives the maximum common gain of utility to the persons concerned in the exchange—in other words, that which coincides with what is socially desirable from a Hedonist point of view. Any interference with a free market and the prices which it tends to establish will accordingly reduce, and not augment, this common gain.

Prices are viewed simply as the resultant of subjective valuations in the minds of the individuals concerned. Expressed in the simple form of two commodities being bartered against one another, the problem does not give much room for dispute; and in the manner of treatment of the simplest case the underlying unity of modern economics is typified. But when

[1] This was the view of Jevons. It has since been established that under direct barter the conditions do not suffice to give a single solution.

we depart from this abstract case and approach nearer to the conditions of the economic world, where exchange is generally not between owners of stocks of two commodities but between producers and consumers, and where the buyer is concerned not with one isolated transaction but with a multitude of related transactions, a number of complications arise; and it is in their different handling of these complications that the differences between schools of economists subsequent to Jevons mainly consisted. To a considerable extent, therefore, the differences between these schools is purely formal.

SUBJECTIVE "REAL COST"

The first set of complications arises when allowance is made for the fact that in the modern commercial world the goods which he sells have no direct utility to the seller: they are "worth" to him merely what they have cost. His willingness to sell is a function, not of their utility to him (as in our corn and cloth example), but of their cost. An analysis of cost is therefore required. Here it would seem that economists had returned to the issue which principally exercised their classical forebears. The cost of a finished commodity consists of the price paid to the factors of production required to produce it. The problem becomes one of determining the value of the factors of production, land, labour and capital. Much confusion indeed has been caused by the habit of economists of labelling this part of their enquiry "Distribution," and imagining that here they were adequately answering the same questions as the Physiocrats and Ricardo were doing. Actually the issue was, in large part, a different one. The classical question was mainly one of the *share* (of the total produce) accruing to different social classes and the contrasting characteristics of these shares. The new question was simply one of the market price per unit of the constituent commodities which entered into the creation of finished commodities. The factors of production, whether they were treated as three in number or twenty, were simply these constituent commodities; and for the purpose of this enquiry they were differentiated among themselves by no more fundamental characteristics than those which marked the x's and y's of our cloth and corn example. To enquire into their value was simply to add certain additional variables to the set of simultaneous equations, requiring the addition of a similar number of fresh equations to complete a solution. They were part of the conditions of simultaneous equilibrium of finished and intermediate (or instrumental) commodities.

The Austrians adopted a simple condition in order to solve this problem. They assumed the quantity of the agents of production to be independently determined. By "independent," for this purpose, they meant that changes in the supply of them did not depend on the price of these agents or of commodities, or on any other of the variables directly involved in the problem. Hence the supply of land, labour and capital could be treated for any one problem as fixed: they could figure in the equations as "constants." The problem had then a simple solution: the value of each factor could then be expressed simply as a function of the prices of the commodities which it produced. This is the famous "Theory

of Marginal Productivity." Given the supply of, say, labour, the supply of labour will tend to be distributed between various sorts of production, so that the value of an increment of product yielded by an increment of labour (its marginal productivity) in all uses is equal; and the value of this increment which the final or marginal unit of labour is responsible for adding to the total produce determines the value of this factor of production. There are, then, *n* additional unknowns in the problem (the price of the *n* factors of production) and *n* additional functional equations.

Walras, and later Cassel, introduced in addition the conception of the "technical coefficients." The production of different commodities will require the factors of production to be combined in different proportions: corn production will require more land relatively to capital than will the production of cloth. The "technical coefficients" for commodity *x* can be expressed by a series representing the quantities of the different factors required to produce a unit of *x*. The weighted average for all commodities (*x*, *y*, *z*) will then give the "technical coefficients" for the economic system in general. Every change in technique will change these "technical coefficients" in particular industries and in industry in general—for instance a new invention which increases the proportion of mechanical power to human labour in some industry or group of industries; and these changes will affect both the prices of commodities and the relative prices of the factors of production.

Jevons, on the other hand, did not make this simplifying assumption concerning the supply of the factors of production, except in the case of land. The supply of labour, for instance, was likely to change with changes in wages, according as a higher wage gave a greater inducement to work harder and longer. The supply of labour, therefore, constituted an additional unknown quantity to determine. Here Jevons consistently applied the same Hedonist concept as he had applied to the problem of demand. As demand could be expressed as a function of "pleasure" or "utility," so the supply of labour could be expressed as a function of the "pain," or "disutility," involved in work. Not the supply of labour itself, but the disutility-function of work, was for him the independent constant by which the problem was resolved. "Labour," he wrote, "will be carried on until the increase of utility from any of the employments just balances the increase of pain. This amounts to saying that . . . the increase of utility derived from the first employment of labour is equal in amount of feeling to . . . the increase of labour by which it is obtained."[1]

This method of handling the problem was extended by Marshall, and with him it became the basis for an attempt to redress the classical conception of "surplus," and to effect a synthesis between the modern and the classical school. We have already noticed that it was never perfectly clear whether the early economists, when they referred to "real cost," conceived of it in an objective or in a subjective sense. In the main, it seems to have had the significance for them of some objective quantity "used up," *e.g.*, corn or the expenditure of physical energy. But already with Smith and McCulloch there were signs of a shifting of the idea to a purely subjective content. With Senior the identification of "real cost" with "sacrifice" was explicit. Jevons' "disutility" and Marshall's

[1] *Theory of Political Economy*, p. 185.

" efforts and sacrifices " were in the direct line of descent from this; and with them the exclusively psychological content of the idea was made abundantly clear. " Sacrifice " was measured, not in any objective quantity, but by the pain or aversion aroused in the mind of the person responsible for this effort or abstinence. For Marshall the labour of the worker and the saving of the investor and the risk-taking of the *entrepreneur* (the " undertaker " of the risks of a business) all involved such a " real cost." To persuade the worker to work, the investor to save, the *entrepreneur* to be enterprising, a reward equivalent to the sacrifice—a utility to balance the disutility—was necessary; and this necessary reward, required to evoke various quantities of labour, capital and enterprise, could be represented as a supply-function or as a schedule of supply-prices. Marshall said : " The exertion of all the different kinds of labour that are directly or indirectly involved in making it, together with the abstinences, or rather the waitings, required for saving the capital used in making it : all these efforts and sacrifices together will be called the *real cost of production* of the commodity. The sum of money that has to be paid for these efforts and sacrifices will be called either its money cost of production or its expenses of production; they are the prices which have to be paid in order to call forth an adequate supply of the efforts and waitings that are required for making it : or, in other words, they are its supply-price."[1] The identification of price with " real cost," be it noted, was only at the margin; and hence the reward of a factor (representing the *marginal* disutility involved in it) would tend to be in excess of the *average* disutility involved. This difference between the sacrifice and reward constituted various species of producers' surplus—a surplus of utility over disutility—which was simply another facet of the so-called consumers' surplus which a consumer enjoyed from the difference between the marginal utility and total utility—the difference between what he pays and what he gets.

Marshall and his school have sometimes been termed the neo-classicists, in contrast to the Austrians and certain of their American followers, such as J. B. Clark and T. N. Carver, who explicitly cut themselves adrift from the earlier Political Economy. The grounds for the label consist in his attempt to preserve the classical conceptions of real cost and of rent. Rent of land, in Marshall's treatment, remained qualitatively distinct from the rewards of other factors of production, for the reason that the supply of land was fixed, independent of human action, and that no " real cost "—no " effort or sacrifice "—was involved in the supply of it. It followed, as an important corollary, that economic rent could be taxed, or otherwise removed, without making the supply of land any the less; whereas to tax wages or interest, by reducing the reward below the necessary supply-price of working and saving, would cause a shrinkage of supply of these factors of production. Marshall was careful, however, to soften the rigidity of the Ricardian distinction. Rent of land appeared to him " not as a thing by itself but as a leading species of a large genus " : elements of " producers' surplus " appeared in incomes earned by other factors of production; and, in particular, capital sunk in buildings and plant bore all the characteristics of land for the period of

[1] *Principles of Economics*, (1890), p. 339.

durability of such capital (for which reason he coined the term *quasi-rent* to designate a short-period view of the return on capital that is immobilised in fixed forms).

In the treatment adopted by the Austrians, on the other hand, and still more clearly in the case of Cassel, the basis for any such distinction entirely disappears: all returns are equally "surpluses" or equally "necessary expenses." The distinction becomes meaningless, since by hypothesis all the factors of production stand on the same footing. The supply of all of them is assumed to be given: no question of a functional relationship between the supply of them and their reward enters in. Explicitly, such writers have declared that the only cost is the loss of the utilities which a factor could have produced if applied in a *different use* from that to which it is actually applied. Cost is simply the other "side of the shield" from utility: it simply consists of utilities of which one is deprived by adopting a certain course of action. The American economist, Davenport has analysed all cost as "opportunity cost." Cassel speaks of the "scarcity-principle" as underlying equally the return to all the factors of production; while in England Wicksteed devoted considerable space to enunciating his thesis that the Ricardian theory of rent was only a special case of the general Theory of Marginal Productivity, and that what could be argued concerning land was equally capable of being argued, on the same assumptions, concerning any of the other factors of production.

GENERAL AND PARTICULAR EQUILIBRIUM

The second set of complications arises when from the simplified case of exchange between two commodities, say cloth and corn, we pass on to more complex considerations of equilibrium in the real world, where purchase and sale of a large range of commodities are continually taking place. In considering the price of any particular commodity, say corn, one must consider it as being exchanged against the whole mass of other commodities or against generalised purchasing power, or money. (The two things come to the same thing, since money has no utility of its own apart from that of the things it can purchase.) Hence the buyers' demand for corn (whether measured in terms of money or of commodities in general) must be expressed as a function not only of the utility of corn, but also of the marginal utility of all other commodities. Any change in the supply, and hence in the marginal utility and price, of any of these other commodities will therefore alter this demand-function. The so-called Lausanne School, represented by Walras and Pareto, have accordingly occupied themselves with this more complex problem of *general equilibrium*, attempting to establish the terms of equilibrium of all commodities by means of a system of simultaneous equations to cover the aggregate of commodities. English and American economists, on the other hand, have in general confined their analysis to the problem of a particular commodity treated in isolation. To make this possible, the assumption is necessary that the price of all other commodities (and hence the marginal utility of money to buyers) is constant; and this requires the further assumption that the commodity in question is so small a part

of the buyers' total expenditure that a change in *its* price exerts no appreciable influence on the price of other commodities (by affecting the demand for them) or on the marginal utility of money to buyers. Such a reaction is regarded as being so small as to be negligible (what mathematicians call of " the second order of small quantities "). A similar assumption has to be made on the side of supply. It has to be assumed that a change in the output of this particular commodity (say, silk stockings) does not appreciably affect the demand for the factors of production (land, labour, capital) and hence does not alter the price of these latter. This assumption will be valid if the production of the commodity in question occupies only a small part of the factors of production in the community at large. When, however, a commodity such as corn is being considered, which bulks large both in the average consumers' expenditure and in the employment of one or more of the factors of production, this convenient assumption breaks down, and a solution is only possible by the more complex methods of the Lausanne School.

ECONOMICS AS AN APOLOGETIC

As we have mentioned, the exponents of the utility theory have commonly underlined a significant corollary of their theory. They have pointed out that the competitive equilibrium which their equations establish represents the system of prices which yields the greatest common gain (of utility) to all the parties concerned. This can be demonstrated to follow as a direct corollary from the cloth and corn example which was cited above. If the seller of cloth, for instance, stopped his exchange of cloth for corn before the equilibrium (or " normal ") rate of exchange was reached, he would be getting a smaller total utility than he might otherwise have done; for the marginal utility of the cloth he possessed would be less than the utility of the corn he *might* have got had he continued the act of exchange further. This will continue to be true up to the point where the utility of the marginal cloth he parts with is equal to the utility of the corn he gets in exchange. And similarly for the seller of corn. Again, it can be easily demonstrated that the distribution of the factors of production between their various uses in such a way as to equalise their marginal yield is the condition of their maximum productivity. This follows for the reason that, if the marginal unit of labour employed in cultivating, say, potatoes is producing more than the marginal unit of labour employed in cultivating carrots, there will clearly be a gain in shifting labour from carrots to potatoes—a gain which will only cease when labour is so distributed between potato-culture and carrot-culture that the marginal productivity of labour in both directions is equal. Hence, any interference with competitive equilibrium, and with the prices which competition tends to establish, is likely to decrease, rather than to increase, economic welfare.

Such conclusions were clearly of very considerable significance; and it seems evident that to establish these important conclusions was the primary concern of the earlier utility theorists. By the middle of the nineteenth century industrial capitalism had won its battle against the old society. There was no longer much need, at least in England, for a cudgel

against the dominance of the landed interest; while America, having no feudal past to hamper it, was born bourgeois from the colonial days. Nor was there any longer the same need to create economic society as a conceptual unity in antithesis to the old authoritarian sanctions. Men were no longer interested in precisely those solutions which were the concern of bourgeois economists a hundred years before. Moreover, the tool which Ricardo had fashioned had been subsequently turned to dangerous uses in the hands of Marx. The new subjective economics, therefore, served a double purpose. It provided a new justification of the bourgeois order, and one more convincing to an age grown sceptical of the "unseen hand" of "natural law." At the same time, as an analysis of market price it provided a technique better suited to the more detailed, more microscopic problems with which the economic system in its maturity increasingly engrossed the minds of its servants.

Actually this imposing apology of *laissez-faire* is hardly more than a clever sleight-of-hand. The corollary follows simply because the necessary conditions to support the corollary are included in the assumptions from which one starts. And since these conditions are implicit in the assumptions, rather than explicit, the corollary can be produced in that atmosphere of surprise which (along with his "patter") is so commonly the conjuror's most valuable stock-in-trade. If two persons are equally situated, they will, by hypothesis, continue to perform the act of exchange with one another until it does not profit them to continue the transaction further; and therefore it follows that their common gain would be smaller if they carried on their transactions either further than or not so far as this point. On the other hand, if the two parties are unequally situated, there is nothing to say that the outcome of free exchange between them would not represent a smaller gain than if they had been less unequally situated, or to say that *laissez-faire* will do anything but perpetuate this inferior state of affairs. Again, Professor J. B. Clark may assure us that he can convincingly demonstrate (by the Theory of Marginal Productivity) that "a natural law exists" which causes "free competition (to tend) to give to labour what labour creates, to capital what capital creates and to *entrepreneurs* what the co-ordinating function creates"[1]; but the fact remains that if society were not a class society, where "labour" is provided by a proletarian class possessing no land or capital, the "creation" attributable to labour and the "creation" attributable to capital would be considerably different from what they are. Here, in particular, the demonstration of an "economic harmony" is a mere trick of words.

Increasingly, indeed, to-day economists are stressing "exceptions" to this supposed harmony of *laissez-faire*; even while they still customarily admit *laissez-faire* as a "general principle." Marshall himself was particularly careful to fence his analysis with a careful regard for the "exceptions" and modifications which special conditions (ignored in the more abstract formulation of theory) imposed. And Professor Pigou, developing certain hints of Marshall, has (in his *Economics of Welfare*) turned a powerful battery against the *laissez-faire* position, stressing the inadequacy of *laissez-faire* to achieve the *optimum* result in the case of

[1] *Distribution of Wealth* (1899), p. 3.

industries subject to "increasing returns" (or decreasing cost) as the scale of production is expanded and in the case of various social costs and social utilities which do not figure in the economic calculations of individuals. At any rate, with the competitive capitalism of the nineteenth century passing increasingly into the monopolist capitalism of the twentieth century, discussions of the value of competitive equilibrium retain little more than their academic interest; and the increasing need of the new capitalist forms for systems and methods of economic control, whether by the State, public corporations, or trade associations, has rendered the vindication of *laissez-faire* largely otiose.

It is, however, in the realm which economists term "the Theory of Distribution" that the modern proletarian challenge to capitalism has mainly come; and here economic theory is still successful as an apologetic. Not all economists may be so daring in their verbal agility as Professor Clark. Few to-day would join him in explicitly enunciating that the distribution of income is governed by "the hidden hand" of "natural law." Yet the theory that the returns to labour and capital correspond to the "effort and sacrifice" involved is a definite bulwark against Marxist criticism. Interest and profit, as well as wages, are the "necessary" rewards for an essential economic contribution; and without the reward the contribution would not be forthcoming. True, rent remains as a surplus, a deduction from producers for the enrichment of a passive class. But pure economic rent to-day, when land has been improved by decades of capital investment, represents only a relatively small portion even of the return to land, while "surplus" elements are also found in other incomes, including wages. Marshall's theory of "normal profit" was clearly fashioned to demonstrate that, from a long-period standpoint, profit contains no surplus, no "non-necessary" element; while Cassel is at pains to demonstrate, by the "scarcity principle," that interest would still exist in a socialist State.[1] Welfare may be augmented by any measures which reduce the inequality of incomes; certain surplus-elements in income may be desirably appropriated by the community for the common good. Still, economic theory postulates various limits to such remedial action in the connection which exists between incomes and the supply of necessary services. At any rate, even in the treatment of the matter by J. A. Hobson (who has carried Marshall's surplus and supply-price distinction furthest), there appears no defined class antithesis between qualitatively contrasted class-incomes—an antithesis such as figured in the treatment of Ricardo and Marx, holding the possibility of a revolutionary change of institutions.

To the extent that Economics concerns itself with this type of consideration, it is clearly attempting to answer somewhat similar questions to those which the older Political Economy sought to answer. Most noticeably with Marshall, we find the attempt to use the new technique and to fit it to a classical framework. Yet we have suggested that it has really set out to answer not the same but a different set of questions. Is it then competent to answer the former, as well as the latter questions? Or is it claiming competence over a sphere from which it is properly debarred by

[1] *Theory of Social Economy* (1923), vol. i, chapter vi.

the very assumptions which lie implicit in its method of enquiry? Clearly, if modern economics is simply a theory of market price and no more, it cannot provide a criterion by which to gauge the significance of any particular arrangement of prices. Being simply a theory of equilibrium —a group of equations showing the relationship between a system of variables—it can do no more than postulate the system of prices appropriate to a number of possible situations (for instance the prices appropriate to a competitive situation, on the one hand, and to monopoly, on the other; to a class society and a classless society). It says nothing about the relative character or significance of these various situations; and hence it can make none of the *normative* judgments which economics is usually required to make, for the simple reason that a mere system of simultaneous equations by itself contains no norm (or standard). It was such a norm that the old Political Economy sought to provide in its theory of value (as distinct from market price). But a mere equilibrium theory, which expresses market price as a function of certain variables, cannot itself supply such a norm.

It is in providing such a norm to a simple equilibrium theory that the Hedonist basis of the utility theory has its importance. For a pure theory of equilibrium such a basis is quite unnecessary, as various writers such as Pareto and later Cassel have indicated. It is sufficient for the theory of price to postulate simply certain *choices*—to take the observed fact of a certain scale of preferences among consumers as between different goods. Nothing need be assumed concerning the *significance* of these preferences —whether the market's preference for cocaine, quack-medicines or diamonds is because they yield more satisfaction or welfare than opera and working-class houses. Given one set of preferences, there will be a set of prices appropriate to them; to another set of preferences another set of prices. There is nothing postulated about the value of the first set of preferences against the second. This may be very convenient so far as a mere equilibrium theory goes—more economical in its hypotheses. At the same time, without these further inconvenient assumptions one's scope is strictly limited. One cannot say that an economic system which adjusts production so as to satisfy those preferences to the full is any more economically desirable than a system which deliberately ignores those preferences and establishes a set of prices appropriate to something quite different. If, however, one assumes that the demand for goods which is expressed by consumers on the market is a true index of some fundamental satisfaction (the old sense of utility) which they derive from these goods, then one can postulate the conditions under which this satisfaction will be maximised. A criterion then exists by which, for instance, it can be said that the set of prices appropriate to competitive conditions comes nearer to this *optimum* than that appropriate to monopoly. A criterion exists by which it can be said whether an economic society based on the price system and the market is economically preferable to a communist society which strictly subordinates the open market and curtails the price mechanism.

The modern tendency, however, is explicitly to sever this connection between Economics and Hedonism and to define " utility " in a purely empirical, behaviourist sense as measured by a person's observed desire

for a commodity. Cassel goes even further, and bases his theory of price on observed demands on the market *expressed in money*. Price becomes, therefore, on the side of demand a reflection or a product of consumers' preferences, or choices. For the purpose of the equilibrium theory, these choices are taken as ultimate—as the data of the problem. They are "constants," which in the concrete case give the actual numerical value of the equations. But, in fact, these choices are not necessarily the reflection of anything ultimate : they may be arbitrary, ephemeral. They may be the result of a passing whim, of a convention or the creation of a cunning advertiser. They may, indeed, themselves be partly dependent on price—for example, the changes of habits and conventional desires which accompany changes in relative prices or in the general price-level. In Cassel's treatment, indeed, they are largely a function of the distribution of income, not merely through the influence of the distribution of income on conventional standards and desires of different classes, but because the distribution of wealth between rich and poor will *directly* affect the market preference (as expressed in *money-demand*) for, say, rare luxuries as against cheap articles of mass consumption. At any rate, the theory of price endows these market preferences with no other significance than as the *data* for a theory of market equilibrium. In any wider sense they are entirely non-significant.

Some economists, particularly those of the school of Marshall and Jevons, still attempt to retain the old notion of utility as implying satisfaction of *needs*, and so to make economics into a normative science of economic welfare—that is, a science which implies *judgments* as well as merely describing things as they exist. Marshall pointed out (though in no more than a footnote)[1] that *desires* and *satisfactions* may diverge. But since, he said, the measurement of satisfaction is impossible, "we fall back on the measurement which economics supplies of the motive or moving force to action : and to make it serve, with all its faults, *both* for the desires which prompt activities and for the satisfactions that result from them." Following him, Professor Pigou has admitted the possibility of "gap" between them : one may "desire" a patent medicine and at the same time acquire a negative amount of lasting satisfaction from it. But he has suggested that such a divergence is probably not serious in the case of "most commodities, especially those of wide consumption that are required as articles of food and clothing." These, being "wanted as means of satisfaction, will consequently be desired with intensities proportioned to the satisfaction they are expected to yield."[2] This is probably true of prime necessaries—precisely the basic commodities which a communist society, for instance, could distribute without any difficulty on a rationed system, dispensing with a price system. But as soon as we pass from prime necessaries to comforts and semi-luxuries, coincidence of desire and satisfaction seems to become increasingly questionable. In all matters of acquired taste a large number of biassing circumstances seem likely to play a part in determining the taste that is actually acquired. There seems no warrant for assuming that the choice which ultimately results will necessarily be any more conducive to welfare than an

[1] *Principles of Economics*, pp. 92-93.
[2] *Economics of Welfare* (1920), p. 25.

alternative taste which might have been nurtured in a slightly altered set of circumstances. Moreover, purely conventional standards—particularly class conventions—enter surprisingly deeply into nearly all our tastes other than the primary needs of the body—a point which Thorstein Veblen illustrated with so much acumen. And these days, when advertisement plays the prime rôle in business supremacy, thriving as it does on "educating the consumer," afford much temptation to regard consumers' preferences as significant of little else than the persuasive skill of the publicity agent, the poster artist and the insinuating salesman.

For somewhat similar reasons the attempt to base a theory of distribution on a subjective conception of "real cost" seems equally based on shifting sand. The new conception of "real cost" as "effort and sacrifice," which replaces the old classical concepts of an objective "real cost," bears on its face the obvious disadvantage, which we have already mentioned, that it rests on a basic dualism. There is not one type of "real cost" but two; and there is no discoverable means of equating the two by a common term. It is no answer to say that a comparison between the disutility involved in an hour's work and the disutility involved in saving, say, £10 for a year, depends on which a particular individual himself would prefer to do, because such a preference varies with his circumstances—how rich or how poor he is. A more fundamental difficulty than this is the very delimitation of "sacrifice"—the logical difficulty which Senior originally found in knowing whether to define "abstinence" as including or as excluding the "abstaining" from the consumption of wealth that has been inherited. Similarly with the sacrifice involved in "saving" something which has not been expected: is it an equal "sacrifice" to save a "windfall" gain as to save an income that has been fully expected? If the answer is "Yes," the notion of sacrifice seems to fade into a bodiless ghost; if the answer is "No," then the frontier of "sacrifice" turns out to be drawn along the highly unsuitable line of whether the income that is "saved" has been expected or is unexpected. One clearly cannot "sacrifice" what one does not possess; and sacrifice seems, on analysis, to be hardly distinguishable from "opportunity-cost"—from the sacrifice of alternative opportunities. Reduced to these terms, it ceases to have any universal significance as a conception of "real cost"—it will change its coat with every change of regime. At any rate, it will have no significance which makes it at all comparable to the "real cost" involved in working an eight-hour day. If one uses "sacrifice," or "abstinence," in any sense that is at all fundamental, then it is not the rich men of the world who do the "sacrifice" involved in capital accumulation. The "sacrifice" rests in the lowered incomes and narrowed consumption of the proletariat which permits the propertied class to enjoy its privileged income. But the "sacrifice" which in Marshall's theory is the basis of supply-price is clearly nothing so fundamental as this. If Pharaoh lent his slaves for building pyramids, it was not the slaves alone who, in Marshall's sense of the word, performed a sacrifice: Pharaoh bore a "sacrifice," too, proportioned to the alternative enjoyments which his slaves might have yielded if put to other use. That the "real cost" borne by Pharaoh was of the same kind and order as that of the pyramid-building slaves may have been the viewpoint of the

scribes of the Egyptian Court. But from our more detached viewpoint of centuries later, it seems hard to discover any useful sense in which Pharaoh's " sacrifice " was of the same order as that which he would have incurred had he laboured at pyramid-building himself.

Modern economics seems to have developed a technique which may well prove of permanent value, at least in the study of particular detailed aspects of the economic world. Here, it has certainly made a lasting contribution. The conception of the functional equation and of increments at the margin makes possible a precision of thought entirely unattainable before, and renders the study of economic theory an intellectual discipline somewhat akin to the study of mathematics, even if of a more elementary and inferior order. At the same time, the glamour of the technique has been responsible for considerable carelessness in its use. The technique seems to have been put to employments which it is quite unsuited to support, and has become enmeshed in not a little confusion concerning the assumptions on which analysis has been based. By its assumptions modern economics is confined to a limited enquiry—the conditions of market equilibrium in face of a given scale of preferences on the part of consumers and in a given state of supply of the factors of production. That is all it can really ask and answer. Yet economists have generally thought that they were answering—at least their audiences have imagined them to be—the much wider type of questions with which classical Political Economy dealt : questions such as the relation between classes and the comparative merits of different types of economic system. " Economics " and " Political Economy " are something more than differences of name : they are different enquiries, different in scope and aim ; and while the former may be superior in finish and precision, at the same time it is necessarily more limited in its range. Until this fact is faced and realised I believe that little progress in the field of economic analysis will be made.

THE THEORY OF MONEY

One sphere in particular where the technique of modern economic analysis has borne considerable fruit is in the Theory of Money. To this enquiry the modern technique is eminently suited : the question is one of causes of variation in the price relationship of money to commodities in general ; and no deeper assumptions are involved. To a large extent the main lines of the subject were already laid down by Adam Smith and Ricardo ; but a good deal more than mere elaboration has been done by the work of Marshall in England and Irving Fisher in America, and more recently still by R. G. Hawtrey and J. M. Keynes. This has consisted of the formulation of the value, or the purchasing power, of money (or its inverse, the general price-level) in terms of an equation which relates it to the significant variables on which it depends. This is the famous Quantity Theory of Money. By itself it is scarcely more than a truism. It is an equation of identity which of itself gives no key to the causal order of events. But its practical implications are wide and important, and are frequently corollaries which are not immediately obvious to direct common-sense inference from the facts. To the politician as well as to the

man in the street, for instance, the chaos of price changes and of exchange-quotations which characterised the War and post-War years presented something of a bewildering mystery. It was left to the economist to give the rather simple explanation and to produce the recipe for monetary stabilisation after the War. Similarly, to-day, with the much-debated monetary aspects of the trade cycle—that cyclical alternation of trade boom and trade depression which characterises the modern economic system. And it is largely the economists' concern with the study of this special phenomenon that has prompted the most significant developments of monetary theory in recent years. In most pre-War formulations of the Quantity Theory equation the value of money was expressed as a function of the quantity of money in circulation and its velocity of circulation, compared to the output of goods and the volume of transactions. In more recent statements of the theory, emphasis has been placed on the volume of resources which are at any time held in the form of money-balances, principally as bank-deposits. This quantity has taken the place of the velocity of circulation. The demand for money has been conceived as the proportion of the national income of goods and services over which people have desired to hold command in money form; and variations in this quantity have been accorded an equal place with changes in supply of money—at least in the explanation of short-period changes in the price level. More recently still Mr. Keynes, in his *Treatise on Money*, has introduced a new set of equations, in which the relation between Saving (in the sense of money that is not spent) and Investment (in the sense of creation of capital goods, such as factories and plant) plays an important independent rôle in affecting both the price level and the volume of employment: when the former exceeds the latter there is the tendency for the price-level to fall and for unemployment to increase; and conversely when the latter exceeds the former.

CONCLUSION

In America in particular, in recent years, there has developed an important school of economic thought that has studied the future of economics along the lines of inductive enquiry.[1] Aided by the greater wealth of statistics which the modern world, and particularly America, affords, enquiry has proceeded along the lines of the study of business indices and of price-correlations. On the other hand, in Soviet Russia we find economists increasingly occupied with the specialised studies concerned with the concrete problems of economic planning—a development, perhaps, slightly reminiscent of the approach to particular problems of government adopted by the earlier economists prior to the Physiocrats, and particularly by the so-called Cameralists in eighteenth century Germany. It may be that the differential calculus and equations of market equilibrium have said all of which they are capable, and that the future of economic enquiry lies in specialised experimental and concrete studies such as these. Nevertheless, such enquiries can hardly provide more than contributory evidence to the solution of the problems of the general distribution of wealth and

[1] *Cf. The Trend of Economics* (1924), ed. by R. G. Tugwell.

the comparative results of different economic systems. This group of questions—those macroscopic, as distinct from microscopic, issues of the economic order—will still remain to be answered, and to be answered presumably in terms of the concepts which classical Political Economy created.